Table VI-8 Approach for Estimating Excess Risk of MSDs Among Workers Exposed to Risk Factors That Meet the Final Rule's Screen

	A	B	C	D	E	F	G	H	I
SIC	Total No. LWD MSDs[a]	Incidence per 1,000 Workers[b]	Estimated No. Full-Time-Equivalent Workers in SIC[c]	Percent of Workers in Jobs > Screen[d]	Estimated No. of Higher-Risk Workers[e]	Incidence Among Higher-Risk Workers (Pd)[f]	Incidence Among Non-Lower-Risk Workers (Po)[g]	Potentially Preventable Risk Among Higher-Risk Workers (per 1,000) (High Estimate)[h]	Potentially Preventable Risk Among Higher-Risk Workers (per 1,000) (Low Estimate)[i]
07[j]	3,890.0	6.906	563,279	43.20%	243,337	0.01111	0.00370	11.115	7.437
08[j]	144.0	6.738	21,372	43.20%	9,233	0.01084	0.00361	10.844	7.256
09	49.5	4.951	9,998	43.20%	4,319	0.00797	0.00266	7.968	5.326
13	1,075.7	3.170	339,338	43.20%	146,594	0.00510	0.00170	5.102	3.407
20	20,540.1	12.242	1,677,839	43.00%	721,471	0.01975	0.00658	19.745	13.251
21	322.9	8.308	38,866	43.00%	16,712	0.01340	0.00447	13.400	8.973
22	3,483.4	5.626	619,161	43.00%	266,239	0.00907	0.00302	9.074	6.068
23	6,379.6	7.869	810,726	43.00%	348,612	0.01269	0.00423	12.692	8.497
24	9,228.5	12.166	758,548	43.00%	326,176	0.01962	0.00654	19.623	13.168
25	5,892.1	11.741	501,840	43.00%	215,791	0.01894	0.00631	18.937	12.705
26	4,865.2	6.921	702,962	43.00%	302,274	0.01116	0.00372	11.163	7.470
27	9,195.3	6.547	1,404,506	43.00%	603,938	0.01056	0.00352	10.560	7.065
28	3,641.2	3.507	1,038,266	43.00%	446,455	0.00566	0.00189	5.656	3.778
29	432.1	2.956	146,177	43.00%	62,856	0.00477	0.00159	4.768	3.184
30	11,982.7	12.069	992,849	43.00%	426,925	0.01947	0.00649	19.466	13.062
31	856.4	9.226	92,825	43.00%	39,915	0.01488	0.00496	14.881	9.970
32	6,316.4	11.444	551,940	43.00%	237,334	0.01846	0.00615	18.458	12.382
33	8,940.0	12.099	738,904	43.00%	317,729	0.01951	0.00650	19.515	13.095
34	17,751.1	12.121	1,464,491	43.00%	629,731	0.01955	0.00652	19.550	13.119
35	17,124.5	7.946	2,155,109	43.00%	926,697	0.01282	0.00427	12.816	8.581
36	10,782.5	6.506	1,657,316	43.00%	712,646	0.01049	0.00350	10.494	7.020
37[j]	22,581.0	15.866	1,423,274	43.00%	612,008	0.02559	0.00853	25.590	17.206
38	4,036.9	4.785	843,657	43.00%	362,773	0.00772	0.00257	7.718	5.158
39	3,375.8	8.997	375,214	43.00%	161,342	0.01451	0.00484	14.511	9.721
41	4,617.3	14.671	314,723	47.60%	149,808	0.02255	0.00752	22.548	15.146
42	23,800.1	14.438	1,648,435	47.60%	784,655	0.02219	0.00740	22.190	14.903
44	1,537.1	9.959	154,343	47.60%	73,467	0.01531	0.00510	15.306	10.256
45	34,150.0	36.580	933,570	47.60%	444,379	0.05622	0.01874	56.219	38.195
46[j]	194.0	12.878	15,065	47.60%	7,171	0.01979	0.00660	19.791	13.282
47	1,263.1	3.262	387,216	47.60%	184,315	0.00501	0.00167	5.013	3.348
48	5,708.2	4.398	1,297,908	47.60%	617,804	0.00676	0.00225	6.759	4.516
49	5,712.1	6.478	881,769	47.60%	419,722	0.00996	0.00332	9.956	6.659

Table VI-8 Approach for Estimating Excess Risk of MSDs Among Workers Exposed to Risk Factors That Meet the Final Rule's Screen (Continued)

	A	B	C	D	E	F	G	H	I
SIC	Total No. LWD MSDs[a]	Incidence per 1,000 Workers[b]	Estimated No. Full-Time-Equivalent Workers in SIC[c]	Percent of Workers in Jobs > Screen[d]	Estimated No. of Higher-Risk Workers[e]	Incidence Among Higher-Risk Workers (Pd)[f]	Incidence Among Non-Lower-Risk Workers (Po)[g]	Potentially Preventable Risk Among Higher-Risk Workers (per 1,000) (High Estimate)[h]	Potentially Preventable Risk Among Higher-Risk Workers (per 1,000) (Low Estimate)[i]
50	26,782.1	7.235	3,701,742	42.70%	1,580,644	0.01171	0.00390	11.707	7.835
51	24,768.4	9.792	2,529,453	42.70%	1,080,076	0.01584	0.00528	15.845	10.619
52	8,621.9	10.699	805,860	35.10%	282,857	0.01886	0.00629	18.858	12.652
53	22,395.6	11.152	2,008,214	35.10%	704,883	0.01966	0.00655	19.657	13.191
54	25,268.9	10.191	2,479,531	35.10%	870,315	0.01796	0.00599	17.963	12.047
55	10,347.3	4.847	2,134,784	35.10%	749,309	0.00854	0.00285	8.543	5.712
56	2,439.1	3.132	778,768	35.10%	273,347	0.00552	0.00184	5.521	3.687
57	6,016.1	7.136	843,063	35.10%	295,915	0.01258	0.00419	12.578	8.421
58	14,457.5	2.830	5,108,657	35.10%	1,793,139	0.00499	0.00166	4.988	3.331
59	10,043.2	4.857	2,067,778	35.10%	725,790	0.00856	0.00285	8.561	5.724
60	2,487.7	1.355	1,835,941	21.00%	385,548	0.00286	0.00095	2.863	1.910
61	399.3	0.810	492,963	21.00%	103,522	0.00171	0.00057	1.711	1.141
62	276.7	0.533	519,137	21.00%	109,019	0.00113	0.00038	1.126	0.751
63	2,659.1	2.068	1,285,832	21.00%	270,025	0.00437	0.00146	4.369	2.917
64	472.2	0.733	644,202	21.00%	135,282	0.00155	0.00052	1.549	1.033
65	5,882.8	5.113	1,150,557	21.00%	241,617	0.01080	0.00360	10.802	7.227
67	297.6	1.579	188,474	21.00%	39,579	0.00334	0.00111	3.336	2.226
70	11,241.0	8.216	1,368,184	36.60%	500,755	0.01423	0.00474	14.231	9.533
72	3,527.2	3.865	912,600	36.60%	334,012	0.00669	0.00223	6.695	4.473
73	16,706.8	3.564	4,687,654	36.60%	1,715,681	0.00617	0.00206	6.173	4.124
75	4,347.9	4.422	983,243	36.60%	359,867	0.00766	0.00255	7.659	5.119
76	2,274.4	6.506	349,585	36.60%	127,948	0.01127	0.00376	11.269	7.541
78[j]	3,614.0	7.072	511,031	36.60%	187,037	0.01225	0.00408	12.249	8.200
79	5,805.4	5.857	991,190	36.60%	362,776	0.01014	0.00338	10.145	6.786
80	103,478.7	13.847	7,473,005	36.60%	2,735,120	0.02398	0.00799	23.984	16.118
81	1,264.4	1.524	829,659	36.60%	303,655	0.00264	0.00088	2.640	1.761
82	2,926.6	2.681	1,091,608	36.60%	399,528	0.00464	0.00155	4.644	3.101
83	13,755.1	7.483	1,838,180	36.60%	672,774	0.01296	0.00432	12.961	8.678
84[j]	319.0	3.994	79,862	36.60%	29,229	0.00692	0.00231	6.919	4.623
86	1,838.5	2.745	669,763	36.60%	245,133	0.00475	0.00158	4.755	3.175
87	5,653.6	2.114	2,674,361	36.60%	978,816	0.00366	0.00122	3.662	2.444
89[j]	761.0	7.193	105,803	36.60%	38,724	0.01246	0.00415	12.458	8.340
TOTAL	590,998		77,702,172		29,454,352				

[a, b] OSHA estimates based on 1996 BLS data (Ex. 26-1413).

[c] (Col A/Col B) * 1000

[d] Data from Washington State Industry Survey, see Chapter 4 of Final Economic Analysis.

[e] Col C * Col D

[f] (Col B)/[Col D + ((1-Col D)/3)], see Chapter 4 of Final Economic Analysis for derivation.

[g] [Col A - (Col E * Col F)]/(Col C - Col E)

[h] Col F * 1000

[i] (Col F - Col G)/(1 - Col G)

[j] Estimated number of MSDs represents the sum of estimates for industry sectors at the 3-digit SIC level to exclude industry sectors not covered in the final rule and to include include data for industry sectors for which BLS did not provide an estimate at the 2-digit SIC level. Estimates of the numbers of MSDs and employees are taken from Chapter 2 (Industry Profile) of the Final Economic Analysis

Assuming that there is a three-fold higher risk of MSDs among higher-risk workers compared with lower-risk workers, the incidence of MSDs among higher-risk employees is estimated for each industry sector by the following formula:

$$\frac{MSDInc_{tot}}{Pct_E - \left[\left(1 - Pct_E\right)/RR\right]}$$

where:

$MSDInc_{tot}$ is the MSD incidence among all workers in the industry sector;

Pct_E is the percentage of workers in the industry sector who are considered to be regularly exposed to risk factors at levels that meet the final rule's screen; and

RR is the risk ratio of 3.

The derivation of this formula appears in Chapter 3 (Benefits) of OSHA's Final Economic Analysis.

TABLE VI–9.—SUMMARY OF RISK RATIOS IN THE EPIDEMIOLOGICAL LITERATURE FOR MSDS REVIEWED BY OSHA, AND ESTIMATED FRACTION OF MSDS ATTRIBUTABLE TO WORKPLACE EXPOSURE

	Body part affected/disorder							
	Neck or neck/ shoulder	Only shoulder	Elbow	Carpal tunnel syndrome	Hand/wrist tendinitis	Hand/arm vibration	Back	Lower extremity
Number of Studies Included ..	42	32	18	30	10	12	44	9
Risk Ratios [a]								
Median	2.7	3.3	2.8	3.2	3.7	6.6	1.85	2.2
Average	4.5	5.2	5.5	4.4	6.5	12.6	2.66	2.4
Estimated Percent of MSDs Attributable to Exposure to Risk Factors [b]								
Median	63.0	69.5	63.6	68.5	72.6	84.8	45.9	53.5
Average	77.6	80.6	81.9	77.5	84.6	92.1	62.4	58.9

[a] Risk ratios include odds ratios, prevalence rate ratios, and incidence ratios.

[b] Proportion of disorders among exposed workers that is attributable to their exposure at work; calculated as (RR–1)/RR, where RR is the median or average risk ratio derived from each group of epidemiological studies.

Source: Data presented in Tables V–1 through V–6 of the Health Effects section (Section V).

The MSD incidence among lower-risk employees in each industry sector is estimated as the ratio of the number of MSDs that occurred in 1996 among lower-risk employees to the estimated number of lower-risk employees in each industry sector (see formula in Table VI–8).

The portion of the risk for higher-risk employees that can be attributed directly to workplace exposure to risk factors (*i.e.,* that portion of the risk that is potentially preventable) lies between two extremes, the upper and the lower bound of the range of estimated risks. OSHA estimated the upper bound of the range to be equal to the MSD incidence among higher-risk employees; this bound assumes that the BLS data includes no cases reflecting background risk, since all of the MSD cases in the BLS data are work-related. The lower bound, on the other hand, assumes that the MSD incidence among lower-risk employees is entirely attributable to background, *i.e.,* that work did not contribute in any of the MSD cases reported among lower-risk workers. To estimate the lower bound, OSHA estimated the excess risk among higher-risk workers from the general formula that the Agency has used in previous risk assessments to estimate excess risk. The general formula for estimating excess risk is

$$\frac{P_d - P_0}{1 - P_0}$$

where P_d is the probability of injury or illness among workers exposed to a hazard and P_0 is the background risk that occurs among persons who are not exposed to the hazard. In this case, P_0 represents the estimated MSD incidence among workers who are either not exposed to risk factors at work or who are exposed to risk factors below the level meeting the final rule's screen.

As with the first risk assessment approach discussed above, OSHA also estimated the lifetime risk of experiencing a LWD MSD to workers who work in jobs that meet the final rule's basic screening tool. Estimates representing the risk of experiencing at least one MSD and the average number of MSDs per worker (*i.e.,* the expected value) were calculated assuming a 45-year working life. Table VI–10 presents OSHA's estimates of the lifetime risk of experiencing work-related MSDs, by industry sector; lifetime risks were calculated based on both the upper- and lower-bound estimates of the MSD incidence among higher-risk employees (*i.e.,* those exposed to risk factors at levels meeting the final rule's screen). Based on the probability approach, the estimated probability that a higher-risk worker will experience at least one work-related MSD during a working lifetime ranges from 33 per 1,000 workers to 926 per 1,000 workers, depending on the industry sector. Based on the expected value approach, the expected number of work-related MSDs that will occur in a cohort of higher-risk workers all entering an industry at the same time ranges from 34 per 1,000 workers to 2,530 per 1,000 workers, since this approach recognizes that it is possible for a worker to experience more than one work-related MSD in a working lifetime.

Table VI-10. Estimated Excess Risk of Developing a Work-Related MSDs Over a 45-Year Working Lifetime Among Employees Exposed to Risk Factors In Excess of the Final Rule's Screen (Adjusted for Background)

Two Digit SIC	Industry Sector	Estimated Number of LWD MSDs Among High-Risk Workers	Estimated Excess Risk per 1,000 Workers		Expected Number of MSDs per 1,000 Workers During a Working Lifetime		Number of Workers per 1,000 to have at Least One MSD During a Working Lifetime	
			High Estimate	Low Estimate	High Estimate	Low Estimate	High Estimate	Low Estimate
45	Transportation By Air	24,982.7	56.219	38.195	2,530	1,719	926	827
37	Transportation Equipment	15,661.0	25.59	17.206	1,152	774	689	542
80	Health Services	65,600.2	23.984	16.118	1,079	725	665	519
41	Local and Suburban Transit and Interurban Highway Passinger Transportation	3,377.8	22.548	15.146	1,015	682	642	497
42	Motor freight Transportation and Warehousing	17,411.1	22.19	14.903	999	671	636	491
46	Pipelines, Except Natural Gas	141.9	19.791	13.282	891	598	593	452
20	Food and Kindred Products	14,245.6	19.745	13.251	889	596	592	451
53	General Merchandise Stores	13,855.8	19.657	13.191	885	594	591	450
24	Lumber and Wood Products, Exc. Furniture	6,400.4	19.623	13.168	883	593	590	449
34	Fabricated Metal, Exc. Machinery & Transportation Equipment	12,311.2	19.55	13.119	880	590	589	448
33	Primary Metals	6,200.3	19.515	13.095	878	589	588	447
30	Rubber and Misc. Plastics	8,310.6	19.466	13.062	876	588	587	447
25	Furniture and Fixtures	4,086.5	18.937	12.705	852	572	577	438
52	Building Materials, Hardware, Garden Supply, Mobile Home Dealers	5,334.2	18.858	12.652	849	569	575	436
32	Stone, Clay, Glass, Concrete Products	4,380.7	18.458	12.382	831	557	568	429
54	Food Stores	15,633.5	17.963	12.047	808	542	558	420
51	Wholesale Trade-Nondurable Goods	17,113.4	15.845	10.619	713	478	513	381
44	Water Transportation	1,124.5	15.306	10.256	689	462	500	371
31	Leather and Leather Products	594.0	14.881	9.970	670	449	491	363
39	Misc. Manufacturing Industries	2,341.3	14.511	9.721	653	437	482	356
70	Hotels, Rooming Houses, Camps, Other Lodging	7,126.2	14.231	9.533	640	429	475	350
21	Tobacco Products	223.9	13.4	8.973	603	404	455	333
83	Social Services	8,720.0	12.961	8.678	583	391	444	324
35	Industrial and Commercial Machinery & Computer Equipment	11,876.7	12.816	8.581	577	386	440	321
23	Apparel and Other Finished Products Made From Fabric	4,424.6	12.692	8.497	571	382	437	319
57	Home Furniture, Furnishings, And Equipment Stores	3,722.1	12.578	8.421	566	379	434	317
89	Services, Not Elsewhere Classified	482.4	12.458	8.340	561	375	431	314
78	Motion Pictures	2,291.1	12.249	8.200	551	369	426	310
50	Wholesale Trade - Durable Goods	18,504.8	11.707	7.835	527	353	411	298
76	Miscellaneous Repair Services	1,441.9	11.269	7.541	507	339	399	289
26	Paper and Allied Products	3,374.3	11.163	7.470	502	336	397	286
7	Agricultural Services	2,704.6	11.115	7.437	500	335	395	285
8	Forestry	100.1	10.844	7.256	844	327	388	279
65	Real Estate	2,610.0	10.802	7.227	486	325	387	278
27	Printing, Publishing, and Allied Industries	6,277.4	10.56	7.065	475	318	380	273

Table VI-10. Estimated Excess Risk of Developing a Work-Related MSDs Over a 45-Year Working Lifetime Among Employees Exposed to Risk Factors In Excess of the Final Rule's Screen (Adjusted for Background)

Two Digit SIC	Industry Sector	Estimated Number of LWD MSDs Among High-Risk Workers	Estimated Excess Risk per 1,000 Workers		Expected Number of MSDs per 1,000 Workers During a Working Lifetime		Number of Workers per 1,000 to have at Least One MSD During a Working Lifetime	
			High Estimate	Low Estimate	High Estimate	Low Estimate	High Estimate	Low Estimate
36	Electronic and Other Electrical, Exc. Computer Equipment	7,478.2	10.494	7.020	472	316	378	272
79	Amusement and Recreation Services	3,680.3	10.145	6.786	475	305	368	264
49	Electric, Gas, and Sanitary Services	4,178.7	9.956	6.659	448	300	363	260
22	Textile Mill Products	2,415.9	9.074	6.068	408	273	336	240
59	Miscellaneous Retail	6,213.6	8.561	5.724	385	258	320	227
55	Automotive Dealers and Gasoline Service Stations	6,401.7	8.543	5.712	384	257	320	227
9	Fishing, Hunting, and Trapping	34.4	7.968	5.326	359	240	302	214
38	Measuring, Analyzing, and Controlling Instruments; Photo, Medical, Optical; Watches, Clocks	2,799.8	7.718	5.158	347	232	394	208
75	Automotive Repair, Services, and Parking	2,756.3	7.659	5.119	345	230	292	206
84	Museums, Art Galleries, and Botanical and Zoological Gardens	202.2	6.919	4.623	311	208	268	188
48	Communications	4,175.9	6.759	4.516	304	203	263	184
72	Personal Services	2,236.1	6.695	4.473	301	201	261	183
73	Business Services	10,591.3	6.173	4.124	278	186	243	170
28	Chemicals and Allied Products	2,525.3	5.656	3.778	255	170	225	157
56	Apparel and Accessory Stores	1,509.0	5.521	3.687	248	166	221	153
13	Oil and Gas Extraction	747.9	5.102	3.407	230	153	206	142
47	Transportation Services	924.0	5.013	3.348	226	151	202	140
58	Eating and Drinking Places	8,944.6	4.988	3.331	224	150	202	139
29	Petroleum Refining and Related Industries	299.7	4.768	3.184	215	143	194	134
86	Membership Organizations	1,165.5	4.755	3.175	214	143	193	133
82	Educational Services	1,855.3	4.644	3.101	209	140	189	130
63	Insurance Carriers	1,179.7	4.369	2.917	197	131	179	123
87	Engineering, Accounting, Research, Management, And Related Services	3,584.1	3.662	2.444	165	110	152	104
67	Holding And Other Investment Offices	132.0	3.336	2.226	150	100	140	95
60	Depository Institutions	1,103.7	2.863	1.910	129	86	121	82
81	Legal Services	801.6	2.64	1.761	119	79	112	76
61	Non-depository Credit Institutions	177.2	1.711	1.141	77	51	74	50
64	Insurance Agents, Brokers, And Service	209.5	1.549	1.033	70	46	67	45
62	Security And Commodity Brokers, Dealers, Exchanges, And Services	122.8	1.126	0.751	51	34	49	33
	TOTAL	389,118						

Source: Estimated Incidence of MSDs provided by BLS for disorders classified by injury and exposure events shown in Table VI-3.
Lifetime risk estimates calculated by OSHA using methods described in the text.

Several rulemaking participants commented on the results of OSHA's preliminary risk assessment and the approaches taken by the Agency to estimate the magnitude of MSD risks to employees.

In their post-hearing submissions (Exs. 500–221, 500–223), Keller & Heckman presented an alternative risk analysis that they believe could be used to compare work-related risks to the background risk of MSDs. Citing the work of Maizlish *et al.* (Ex. 26–1186), they stated that the background risk of carpal tunnel syndrome (CTS) is 1.05 cases per 1,000 person-years; this estimate is based on an analysis of medical records in Rochester, Minnesota, between 1961 and 1980 (Stevens *et al.,* Ex. 26–1009). Using OSHA's estimates from the preliminary risk assessment of the total number of MSDs in U.S. industry for each of the six injury categories selected by OSHA, Keller & Heckman estimated a background incidence for each of the six injury types based on the ratio of the number of LWD cases for each injury type to the number of LWD CTS cases. For example, since OSHA's estimates of the number of LWD strains, sprains, and tears is 16.88 times higher than the number of LWD CTS cases, Keller & Heckman estimated that the background rate of LWD strain, sprain, and tear injuries in the U.S. population is 17.72 cases per 1,000 people per year (*i.e.,* 16.88×1.05). Across all six injury types, Keller & Heckman estimated the background rate for all LWD MSDs to be 22.83 cases per 1,000 persons per year for the U.S. population. They also estimated the MSD rate across the U.S. workforce to be 6.55 LWD MSD cases per person-year, by dividing the total estimated number of MSDs in 1996 (647,344) by private industry employment for 1996 (98,772,900 workers). From this analysis, Keller & Heckman concluded that there is no significant excess risk of MSDs in private industry, since the estimated background rate of MSDs in the *general* population is about 3.5 times higher than the rate that they estimated for the U.S. workforce. They presented similar estimates of MSD rates for selected industry sectors at the 3-digit SIC level and concluded that (1) only 10 of the hundreds of industry sectors covered by the ergonomics program rule have an MSD incidence that exceeds their estimated background rate of MSDs, and (2) that there is no excess risk of work-related MSDs in either SIC 204 (Grain Mill Products), SIC 206 (Sugar and Confectionary Products), or SIC 331 (Steel Works, Blast Furnaces, and Rolling Mills).

OSHA believes that the analysis conducted by Keller & Heckman is seriously flawed in a number of respects. First, Keller & Heckman make an improper comparison between estimated MSD rates in the working population, based on the BLS data, and estimated MSD rates in the *general* population, based on community medical records for the rate of CTS in Rochester, Minnesota. As explained in part B above, the BLS injury and illness survey is not designed to capture all injuries and illnesses that occur among workers; it is only designed to capture those that employers have determined to be work-related. In contrast, the Rochester study on which Keller & Heckman's analysis rests involved *all* cases of CTS that occurred in the community, regardless of whether those cases were work-related or not. These two statistics are not comparable in any meaningful way. To make a meaningful comparison, one would need to have data that permit estimates to be made of the *total* MSD rate in the U.S. workforce, not just the work-related component.

Second, Keller & Heckman assume that the ratio between the number of one type of MSD to that of another will mirror the ratio of the incidence rates for the two types of MSDs in the general population. However, the ratio between the number of cases of two medical conditions can be equal to the ratio of the incidences of those conditions *only* if the cases of both medical conditions are drawn from the *same* population. Clearly, the population from which the BLS data are drawn differs from the general U.S. population in many ways. Consequently, OSHA believes that it is not possible to reliably estimate the background rate of any type of MSD in the general population from the ratio between two MSD types seen in the working population, and therefore the assumption made by Keller & Heckman in conducting their analysis is not supportable.

Third, Keller & Heckman's analysis interprets the rate of CTS in the Rochester, Minnesota, population as the ''background'' rate of CTS. However, the study by Stevens *et al.* (Ex. 26–1009) made no effort to evaluate the work-relatedness of the CTS cases identified from the medical records, nor was there any mention of the investigators collecting work histories or assessing the work status of the cases identified. The Maizlish study (Ex. 26–1186) cited by Keller & Heckman was a study of a California surveillance system for work-related CTS, in which the Rochester CTS rate was used as a reference point for the purpose of identifying ''epidemic clusters'' of CTS (defined as a rate twice that of the Rochester CTS rate). Although the authors of this study refer to the Rochester CTS rate as a ''background'' rate, their rate is clearly not a background rate as that term is used in occupational epidemiology. It cannot represent the rate of CTS among persons without workplace exposure because the CTS cases in the Maizlish study were drawn from the entire Rochester population, which included both workers and non-workers.

For these reasons, OSHA finds the analysis provided by Keller & Heckman both methodologically flawed and unconvincing. The Agency believes that its own risk analysis, which is based on estimates of the numbers of higher-risk and lower-risk workers and on the extensive epidemiological data presented in Section V of this preamble, appropriately takes account of that portion of the MSD rate among workers that is attributable to their workplace exposures.

Keller & Heckman (Exs. 500–221, 500–223) also claim that the ''aggregate risk (workplace and non-workplace risk combined)'' of a U.S. worker experiencing an LWD MSD due to anything that might be defined as a harmful physical agent would be no more than 0.7 per 1,000 workers per year. They arrive at this rate by dividing the 1996 number of BLS MSD cases caused by repetition by total private industry employment. This estimate ignores the LWD cases attributed in the BLS data to overexertion or to awkward postures (*i.e.,* ''bending, climbing, crawling, reaching, twisting''), both of which are exposure event codes that OSHA has determined to be highly relevant for assessing MSD risks to workers. Second, Keller & Heckman characterize their aggregate risk rate as reflecting both workplace and non-workplace contributions to MSD risk. Since the rate Keller & Heckman use is derived from BLS data, which reflects work-related cases exclusively, OSHA does not agree with this characterization.

The National Coalition on Ergonomics (Ex. 32–368) and the American Iron and Steel Institute (Ex. 32–206) objected to the fact that OSHA did not modify its risk estimates from the BLS data by reducing them to account for MSDs that occurred in jobs that would not pass the screening criteria in § 1920.902 of the proposal. In the final ergonomics program rule, OSHA has modified its screening criteria from the performance-oriented language contained in the proposal to be more specific in terms of the kinds and durations of exposures to risk factors that warrant further hazard analysis by the employer. Employers are not expected to conduct job hazard analysis or provide medical management of MSDs for employees in jobs where the exposures to risk factors are below those in the final rule's action trigger. As described above, OSHA has now modified its risk assessment to estimate the number and incidence of MSDs that occur each year among workers who are in jobs in which exposures meet the action trigger. Thus, OSHA's final risk assessment reflects the excess MSD risks among the more highly exposed portion of the worker population covered by the standard.

The Center for Office Technology (COT) (Ex. 30–2208) and the Puerto Rico Manufacturing Association (Ex. 30–3348) took issue with OSHA's statements in the preliminary risk assessment and significance of risk analysis for the proposed rule that the BLS data understate risk. For example, COT commented that

> * * * BLS in their reports state that there is ''95% confidence that the 'true' incidence rate falls within the confidence interval * * * and has an estimated relative standard error of about 0.9 percent.'' BLS does not state that their estimates of injury and illnesses reflect under reporting. Assistant Secretary Charles Jeffress is also on the record supporting the accuracy of the BLS data and is quoted * * * as saying ''90% of employers keep accurate records 95% of the time, or better.'' (Ex. 2208, p. 19)

However, OSHA did not base its preliminary determination that work-related MSDs are seriously underreported on the precision (or lack thereof) of the BLS survey. The BLS statement referred to in COT's comment simply reflects the fact that the BLS estimates of work-related injuries and illnesses in the United States are based on a sampling of OSHA 200 logs, not the logs of all employers. Consequently, the estimates generated from the sample of logs have some uncertainty associated with them, which is characterized by a 95% confidence interval around the estimate. The stated precision of the survey data provided by the BLS does not address issues related to the accuracy of the logs that are sampled, just the precision of the *estimates* generated from the sampled logs. OSHA's determination that MSDs are seriously underreported on OSHA logs is based on the findings of several scientific studies and other data that compared MSD rates from logs to those from medical insurance records, records of sick leave, or other sources of data independent from the OSHA logs; these studies were reviewed in Table VII–2 of the preamble to OSHA's proposed rule (64 FR 65982), and in Table VII–1 and OSHA's discussion of the Significance of Risk (Section VII) in this preamble.

According to NIOSH (Ex. 32–450), OSHA's discussion of the limitations on the use of BLS data in the risk assessment section of the preamble is methodologically sound. These limitations include the following characteristics of reported cases:

- The cases reported are only those that employers have agreed are work-related,
- The cases reported are only those that were serious enough to involve at least one day away from work,
- The cases reported do not include other types of work-related MSD cases that rarely, if ever, come to the attention of the employer, and
- The cases reported do not account for the extended or permanent disability that results in employee termination.

In addition, NIOSH points out that some workers with MSD episodes that may represent lost workday cases are reassigned to minimal work activities in order to avoid recording the case as one involving lost workdays. For these reasons, NIOSH agrees that there is a substantial likelihood of under-reporting in the BLS system and that the BLS estimates represent a lower bound of the true risks of work-related MSDs. NIOSH agrees with OSHA that the true incidence of work-related MSDs is greater than indicated by the BLS estimates.

In its pre-hearing comments (Ex. 32–368), the National Coalition on Ergonomics objected to the use of BLS data in risk assessment on the grounds that the data reflect reports by workers to employers rather than medical diagnoses. The BLS data relied on by OSHA in this risk assessment is lost-work-day data, which employers provide to the BLS along with sufficient information about each injury or illness to permit detailed classification of each injury and illness. Thus, the data relied on by OSHA do not represent ''reports by workers to employers'' but cases that employers have determined to be work related and for which they provided detailed descriptions of the nature of the events associated with each case. Further, the Coalition's comment implies that MSD rates would be much lower if they were based on medical diagnoses rather than employer reports. However, evidence in the rulemaking record shows that the opposite result is more likely; several investigators have actually compared MSD rates from the OSHA logs with the rates reflected in other sources of data that report the results of medical evaluations of injuries and illnesses, such as medical insurance records, compensation claims, medical case records, and medical absence records (Exs. 26–28, 26–920, 26–1261, 26–1259, 26–1260). These studies, reviewed in the Significance of Risk section of the preamble (Section VII), have consistently found the MSD rates reported on OSHA logs to be several-fold lower than those derived from medical records data. Thus, OSHA believes that a risk analysis based on accurate reports of the medical diagnoses of work-related MSDs would result in higher risk estimates than those in OSHA's analysis.

The Edison Electric Institute (Ex. 32–300–1) and Southern California Edison (Ex. 30–3284) take OSHA's statement in the preliminary risk assessment that BLS data ''are not easy to use for risk assessment purposes'' to mean that these data are weak. This is not the case nor is it what OSHA meant by this statement. OSHA's statement that the BLS data are not easy to use for risk assessment referred to the fact that the BLS injury and illness classification system does not contain a single injury/illness category that contains data on all relevant MSDs. This fact required the Agency to select injury/illness categories and appropriate exposure event categories to represent the kinds of disorders addressed by the final rule. As discussed above, OSHA has determined both that the BLS data are the best available data for evaluating MSD risks to workers and that OSHA's reliance on these data is appropriate. In addition, these two stakeholders characterize the employment estimates from the U.S. Bureau of the Census as ''another questionable data source'' without providing any justification for this characterization. They also stated that combining these data to calculate MSD rates by occupation ''compounds the flaw.'' In fact, both the BLS and Bureau of Census population data have been used by the Agency to analyze the impact of its rules for several years, are used extensively by other researchers both within and outside the federal government, and represent state-of-the-art programs for conducting and analyzing nationwide surveys of working populations. OSHA knows of no other data sources that could provide more reliable information on occupations and workplace injuries and illness in the United States.

Jesse McDaniel, a Certified Safety Professional from August Mack Inc. (Ex. 30–240), commented on OSHA's use of the BLS data and the preliminary risk assessment. First, Mr. McDaniel stated that injuries that do not involve lost workdays, restricted work, or medical treatment (or diagnosis in the case of an illness) are not recordable cases under OSHA's recordkeeping rules; he believes that OSHA was therefore incorrect in stating in the preliminary risk assessment that the BLS data understate the true MSD risk to workers because it excludes cases that do not involve days away from work. In other words, Mr. McDaniel appears to believe that cases not counted as LWD MSDs in the BLS system are not recordable, and that OSHA's claim that the data understate the true risk is not warranted. OSHA does not agree it was incorrect in making this statement. The data relied on by OSHA for both its preliminary and final risk assessment comes from the detailed employer survey data, which requires employers to provide descriptions of work-related injuries and illnesses only for those cases involving days away from work, *i.e.,* the employer is not required to provide detailed information on other kinds of recordable injuries and illness not involving days away from work. Therefore, OSHA's estimates of LWD MSD rates based on the BLS data do not include the other kinds of recordable MSDs referred to by Mr. McDaniel. He also believes that OSHA inflated its risk estimates by reporting MSD rates per 1,000 workers rather than on a per-100-worker basis, which is the convention used by BLS in reporting injury rates by industry sector and occupation. OSHA used the risk per 1,000 worker metric because OSHA's significant risk range is bounded by the Supreme Court's guidance in the *Benzene* decision, as explained in the preliminary risk assessment. Mr. McDaniel also provided examples that he believes suggest OSHA's estimated LWD MSD rates exceed the BLS-estimated total injury case rates for some industry sectors and occupations. However, since the BLS case rates are reported per 100 full-time-equivalent employees, and OSHA presents its risk estimates conventionally in terms of cases per 1,000 employees, OSHA's rates, as they appear in this risk assessment, must first be divided by 10 to be comparable to the BLS injury case rates. When this adjustment is made, the comparisons made by Mr. McDaniel show that OSHA's estimated MSD rates are *below* the BLS's total injury case rates.

D. Analysis of Ergonomic Program Effectiveness

In the preliminary risk assessment, OSHA evaluated information and data that described the effectiveness of ergonomic interventions and programs similar to those of the proposed ergonomics program standard [64 FR 65943–65975]. These data were drawn from three sources. First, OSHA searched for and evaluated studies that investigated the effect of ergonomic interventions on reducing exposures to workplace risk factors. These included both field and laboratory studies. Second, OSHA compiled a large database of published and unpublished data from case studies that describe the effect of implementing ergonomic programs on workplace MSD injury rates. Finally, OSHA used the findings from the epidemiological studies contained in the NIOSH (1997, Ex. 26–1) review to estimate the potential effectiveness of ergonomics programs. Since publication of the proposal, a substantial number of additional scientific and ergonomic case studies were entered into the record; OSHA has relied on these to revise its effectiveness analysis. The additional information and data entered into the record confirm OSHA's preliminary determination in the proposal that ergonomic programs and interventions are effective both in reducing those forces on the musculoskeletal tissue that have been associated with the development of tissue pathology, and in reducing the incidence of MSDs. In this section, OSHA summarizes these studies and evidence and analyzes the data from these studies to estimate the overall reduction in MSD rates that is likely to occur when employers implement ergonomic programs like the program required by this standard.

The record contains much testimony from scientific experts that ergonomic programs designed to reduce biomechanical load are effective in reducing MSD risk. In its pre-hearing testimony, NIOSH agreed with OSHA's preliminary conclusion that ergonomic programs are effective:

> * * * [T]here are numerous companies which have reported success in using ergonomic programs as a cost-effective way to prevent or reduce work-related MSDs, and reduce lost time by workers with MSDs. Some of these companies also report increases in productivity and workplace morale. The studies—in part summarized in OSHA's preamble, reviewed by the NAS panel—illustrate that interventions, including redesign of tools, machines, and work stations, can reduce workplace hazards and the resulting MSDs. * * *
>
> The effectiveness of ergonomics programs was a resounding message echoed by labor, industry, business, universities, health care, and professional societies at two conferences co-organized by NIOSH and OSHA to stimulate an exchange of information about preventing work-related MSDs. * * * The conferences, attended by over 1,700 people, featured workshops and presentations by industry, labor, and government representatives sharing their successful ergonomics programs and how they have reduced lost work time and cut costs due to injuries and illnesses in a variety of industries and workplaces. * * *
>
> NIOSH believes that the evidence in the scientific literature showing the success of an ergonomics program approach to workplace hazards is strong. Likewise, NIOSH's experience in evaluating the risks of MSDs in a variety of workplaces and our review of information from a variety of sizes of industries has generally shown that using ergonomic programs is an effective way to prevent or reduce work-related MSDs.

(Ex. 32–450–1, pp. 8–10)

Many expert witnesses also testified that, from their experience, ergonomic programs are effective in reducing MSD risks. For example, Dr. Snook testified on the effectiveness of ergonomic programs for reducing the disability from back pain:

> Now, this is what we know about ergonomics and low back disorders. First of all, we know that in heavy manual handling jobs, there is an increased disability from low back pain, as measured in lost work days and restricted duty.
>
> The second thing that we know is that there have been several guidelines developed to help identify the high risk manual handling jobs.
>
> Third, that when these jobs are designed according to the guidelines, the disability from low back pain decreases.
>
> And finally, employers who have used ergonomics programs to identify and control high-risk jobs have found them to be cost effective.
>
> I also believe it is important to acknowledge what we do not know. We simply do not know the * * * [etiology] or the cause of most low back pain.
>
> Some have suggested that this lack of knowledge must constitute a stopping point. Others, however, have demonstrated that this is not a stopping point, that implementing ergonomic intervention[s] and programs to reduce physical loads does reduce the disability from low back pain.

(Tr. 846–847)

Dr. Cherniak testified that the volume of published ergonomics literature itself is indicative of the success of ergonomics interventions:

> The extensive literature review included in this [OSHA's proposed] standard and explosion of the ergonomics literature in industrial countries are testaments to the seriousness of MSDs, but also to the effectiveness of responsive intervention. I would say that medical fields that lack components of prevention and therapeutics do not usually generate expanding literature. They generally lead to dead ends.

(Tr. 1134–1135)

Many other rulemaking participants provided testimony that ergonomics programs reduce disease. Dr. Barbara Silverstein, Research Director for the Safety and Health Assessment and Research Team, Washington State Department of Labor and Industries, testified that ''Reducing exposure to hazardous loads does reduce musculoskeletal disorder prevalence, incidence, and severity.'' (Tr. 17357) Both Drs. Bernacki and McCunney, representing the American College of Occupational and Environmental Medicine, testified that ergonomics programs instituted at their respective universities were very effective in reducing MSD rates and severity. (Tr. 7690–7693) Sherri Gibson, representing the American Industrial Hygiene Association, testified that ''We know the controls and ergonomic programs work, we've seen it time and time again.'' (Tr. 16466) Under questioning by OSHA, Mr. Fernandez, a practicing ergonomist, stated that, although some ergonomic interventions may require more than one attempt and some ''tweaking,'' in his experience he has never seen a case in which an ergonomic intervention or program was ultimately unsuccessful. (Tr. 5427)

In the preliminary risk assessment that accompanied the proposed rule, OSHA relied, in part, on the large body of epidemiological data showing consistent associations between exposure to biomechanical factors at work and an increased prevalence or incidence of MSDs. Although these studies were not designed specifically to determine or measure the effectiveness of ergonomic interventions in working populations studied, OSHA finds that they nonetheless provide highly useful information on the potential for ergonomic interventions to reduce injuries and illnesses; these studies provide this information because they describe the relationship between exposure to the biomechanical risk factors addressed in this final ergonomics program rule and the risk to workers of developing MSDs. The Health Effects section (Section V of the preamble) summarizes the results of more than 170 epidemiological studies overall, more than 60 of which demonstrate that increased MSD risk is related to increased duration and/or magnitude of exposure to biomechanical risk factors. Other biomechanical and biological data reviewed in the Health Effects section provide evidence that excessive force imposed on musculoskeletal tissue, absent sufficient repair and recovery time, is associated with tissue damage that is consistent with the kinds of disorders seen in the working populations studied; thus, this supporting evidence is consistent with the general model that excessive biomechanical loading increases the risk of developing MSDs. At the public hearings, OSHA presented much expert scientific testimony that this general model is supported by high-quality scientific evidence. Although there is evidence that other factors, including individual and non-biomechanical workplace factors (*e.g.,* psychosocial factors), also influence risk, the evidence shows that work-related biomechanical factors act independently of these other factors in increasing MSD risk.

Because of the independent relationship between biomechanical and other risk factors in the etiology of MSDs, a change in worker exposure to biomechanical risk factors would be expected to lead to a corresponding change in worker risk of MSDs. One of the basic principles of public health is that reducing exposure to a substance, agent, or force that has been demonstrated to be harmful to health will reduce the risk of harm; this principle has been the scientific rationale behind all of OSHA's substance-specific health standards. Accordingly, OSHA finds that the strong evidence in the scientific literature relating exposure to biomechanical risk factors to an increased risk of MSDs is, by itself, sufficient evidence for Agency action that will reduce the exposure of workers to biomechanical factors in the workplace. OSHA's determination is supported by the testimony of its witnesses. In his written testimony, Dr. Wells stated that the epidemiological studies involving biomechanical risk factors have found strong and consistent relationships between those risk factors and MSDs, and therefore that reducing exposures to these risk factors is a reasonable strategy for preventing MSDs (Ex. 37–18). Similarly, Dr. Frank commented that the epidemiological evidence and the results of other investigations on the biology of low back pain strongly suggest that reductions in forces exerted on the spine will substantially reduce disability (Ex. 37–27). During questioning at the public hearing, Dr. Frank explained:

> * * * [A]cting on biomechanical risk factors will bring risk reductions according to our understanding of the multifactorial causal process even if we are unable, for example, at the present time to conclusively act to reduce psychosocial factors because we still understand them poorly.
>
> Q: So that given that as a conclusion, then in your opinion does that mean that an OSHA standard aimed at reducing exposure to biomechanical factors in the work place is likely to reduce lost time disability for low back pain?
>
> Dr. Frank: That is what every epidemiologist who understands these methods would say.

Dr. Punnett also explained the importance of findings that biomechanical risk factors act independently from other factors and the implication of those findings on intervention strategies:

> Q: What is so important about this finding that the physical job factors causing MSD are independent of any of these other factors?
>
> Dr. Punnett: Well, that I think leads us fairly directly to the inference that reducing physical work load all other things being equal will reduce the magnitude and/or severity of musculoskeletal disorders. * * * That is that the effect is not confounded by those other factors. And therefore, we can anticipate a benefit proportional to the increase that has been identified with current exposures.
>
> Q: Does this mean that an OSHA standard aimed at reducing exposure to MSD hazards [*i.e.,* biomechanical factors] is likely to prevent work-related MSDs?
>
> Dr. Punnett: I believe so, yes.

Table VI–8 presented summary statistics from the epidemiological studies that OSHA selected for the Health Effects section; these studies include those contained in the 1997 NIOSH review (Ex. 26–1) as well as additional studies in the record. The statistics presented in Table VI–8 include the range in risk ratios reported in these studies, grouped by type of disorder studied, as well as the median and mean of the distribution of these risk ratios. The risk measures in the epidemiological studies include odds ratios, prevalence rate ratios, and (for a few studies) incidence ratios, and approximate the relative risk of musculoskeletal disorders in an exposed worker population compared with that in a referent group. Although the risk ratios reported in epidemiological studies cannot be used directly to measure the effectiveness of ergonomics programs, they do provide information on that part of the MSD incidence seen in workers that can be attributed directly to their exposure to biomechanical risk factors; this portion of the MSD incidence is termed the attributable, or etiologic fraction, and is also the fraction of the MSD incidence seen in worker populations that is potentially preventable.

The concept of an attributable or etiologic fraction is standard in epidemiology, and the concept has been used previously to estimate the attributable fraction of several types of MSDs in working populations. Hagberg and Wegman (1987, Ex. 26–32) reviewed the epidemiological literature and selected 21 studies in which diagnoses of neck and shoulder disorders were made from physical or laboratory examinations. Odds ratio measures from studies describing similar disorders were pooled across studies for common occupations that involved exposures to workplace risk factors, and the authors computed the overall odds ratio for each type of occupation and disorder. In addition, the authors assessed the effect of the exposure to workplace risk factors on MSD risk by computing the etiological fraction in the exposed population; the etiologic fraction was computed only from those odds ratios that were statistically significantly higher than 1. Hagberg and Wegman (1987, Ex. 26–32) found that the etiological fraction ranged from 40 to 99 percent, depending on the specific type of upper extremity disorder. This study thus provides evidence that the potential for ergonomic interventions to reduce MSD incidence among workers is quite high, provided that such interventions reduce worker exposures to biomechanical risk factors.

OSHA's own summary of the risk ratios reported in the epidemiological database, both in the preliminary and final risk assessments, is consistent with the findings of Hagberg and Wegman (Ex. 26–32). The distribution of risk ratios reported in the epidemiology studies relied on by OSHA in the Health Effects section of the preamble indicate that, based on the median of the distribution, between 46 percent (back disorders) and 88 percent (hand-arm vibration syndrome (HAVS)) of the MSDs experienced by workers who have substantial exposure to biomechanical risk factors (*i.e.,* those workers who comprised the exposed cohorts in these studies) can be attributed to their exposure to risk factors, and are therefore potentially preventable by reducing exposure to the biomechanical risk factors that caused them. For upper extremity disorders (excluding HAVS), neck disorders, and shoulder disorders, the attributable fractions based on the median of the risk ratios is between 55 and 65 percent. The mean of the distribution suggests a somewhat higher attributable fraction: 58 percent for back disorders, 93 percent for HAVS, and between 70 and 80 percent for all others.

As discussed above, OSHA has determined that the strength of the epidemiological, biomechanical, and biological data reviewed in the Health Effects section is sufficient to justify the promulgation of an ergonomics program standard to reduce the significant risks of MSDs posed to workers who are exposed to biomechanical risk factors on the job. Nevertheless, the record contains a substantial body of scientific evidence and case reports that demonstrate directly that ergonomic programs designed to reduce exposures to biomechanical risk factors *do* reduce the incidence of MSDs in exposed workers. Some of this evidence was reviewed in the preliminary risk assessment for the proposed rule; however, since publication of the proposal, many additional studies and case reports have been made available in the record. The remainder of this part of OSHA's final risk assessment reviews these studies and reports.

Intervention studies that employ formal scientific methods are particularly compelling and merit special attention. Unfortunately, intervention studies for ergonomics programs are infrequently conducted because they are complex and scientifically challenging because of the lack of control that investigators generally have over workplace conditions. Thirty-four reports of ergonomic interventions in workplaces were identified in the rulemaking record and are summarized in Table VI–11. Each of these 34 reports was characterized by:

• A clearly described intervention,
• Measurable exposure or health effects endpoints
• Acceptable statistical methods, and
• Characterization of exposure or health outcomes both prior to and after intervention.

These 34 studies together represent the best available direct evidence that practical application of the principles and methods of ergonomics in the workplace results in reduced employee exposure to hazards and in a reduced incidence of work-related musculoskeletal disorders. These studies evaluated the effect of ergonomic interventions on risk factor exposure, health outcomes, or both. Of these studies, 22 reported that, after the ergonomic intervention, exposure was reduced, as measured by the magnitude of external stressors (*i.e.*, reductions in repetitions or improved postures) or reduced tissue loading; 12 of these studies also documented reduced MSD rates as measured by injury records or employee symptom reports. OSHA believes that the 12 studies that measured both exposure and outcome effects are particularly strong, and their findings particularly significant, because they provide direct evidence of a relationship between reductions in exposure to biomechanical risk factors and reductions in the incidence of MSD cases or symptoms, findings that are consistent with the model derived from the epidemiological data, which posits that biomechanical risk factors are associated with an increased MSD risk independent of other contributing factors. Ten of the intervention studies documented outcome measures alone and found that injury rates or symptom reports declined following ergonomic interventions. Two studies (Bernacki, 1999, Ex. 38–34; Bohr, 1997, Ex. 38–64) also reported improved recognition of potentially hazardous jobs among the participants in the ergonomics programs studied.

TABLE VI–11.—SUMMARY OF SCIENTIFIC STUDIES DESIGNED TO ASSESS THE EFFECTIVENESS OF ERGONOMIC INTERVENTIONS

Study	Population	Intervention	Analytic method	Exposure outcome	Health effects outcome
Aaras (1994) Ex. 502–252; Westgaard (1985) Ex. 26–787; Westgaard (1984) Ex. 26–1026.	420 female telecommunication assembly workers.	Reduce postural load: individual adjustment of workstation height and angle, increased legroom, suspending hand tools, arm supports, limit vertical dimensions; Design work to reduce postural fixity.	Longitudinal survival analysis (1967–1984). Exposure evaluated by trapezius static load via EMG, postural angles Outcome: signs & symptoms, sick leave due to load-related MSDs. Survival analysis.	Decreased postural load intensity and duration on trapezius, reduce load in hand, reduced shoulder angles.	Reduction in mean sick leave from 22 days to 1.8 days, Reduced turnover from 30.1% to 7.6%, Increased productivity.

TABLE VI–11.—SUMMARY OF SCIENTIFIC STUDIES DESIGNED TO ASSESS THE EFFECTIVENESS OF ERGONOMIC INTERVENTIONS—Continued

Study	Population	Intervention	Analytic method	Exposure outcome	Health effects outcome
Aaras (1997) Ex. 26–63.	20 VDU workers	Forearm support, screen sight angle change.	Laboratory study using open, randomized Graeco-Latin squared trial with five test conditions using keyboard and then using mouse, measurements included descending m. trapezius and erector spinae lumbalis at L3 EMG and inclinometer.	Trapezius load significantly lower with forearm support (both duration and intensity) with both sitting and standing. No significant differences with 15 versus 30 degrees sightline.	
Aaras (1998) Ex. 26–597.	Male VDU workers, 50 per group.	1 new lighting .... 2 new workplace design to support forearms. 3 optical exams and corrections.	Serial interventions in 2 intervention groups, 1 control group, Load measured via EMG and observation, controlled for psychosocial factors at work and home.	Reduced trapezius load in intervention groups after forearm support and optometric corrections, Reduced glare problems in intervention groups.	Reduced trapezius pain, in intervention groups, no change in forearm pain (appeared to be associated with increased mouse use, no change in back pain). Headaches reduced after lighting change, borderline improvement with optometry, Visual discomfort improved with both lighting and optometry
Bernacki (1999) (Ex. 38–34).	University employees, 1992–1998.	Implementation of a program with early diagnosis and treatment, ergonomic assessment and correction: wrist supports, document holders, foot rests, headsets, alternate keyboards, glare screens, chairs, etc.	Longitudinal follow-up of employees reporting to the medical department after policy to include medical workup and ergonomic assessments for UEMSDs starting in 1992. OSHA 200 logs.	Ergonomic assessments (2041), initially with those with UEMSDs for job modifications. By 1994, significantly more assessments on jobs believed to be risky prior to injury.	Incidence rate decreased 80% (6.5 in 1992 to 1.3/1000 in 1998), surgery trend also decreased.
Bohr (1997) Ex. 38–64	600 employees in three departments in a large metropolitan medical center.	Used participatory worker-management ergonomics teams to identify risks and control strategies.	One year longitudinal evaluation of the ability of ergonomic teams to identify problems and design solutions.	14 problems identified and potential solutions considered or identified.	not assessed.
Brission 1999 Ex. 38–92.	627 university employees working 5 or more hours per week with a video display unit.	Ergonomic training to identify postural stressors and make changes in equipment and work activities.	Six month longitudinal comparison of postural stressors and injury statistics in randomly assigned experimental (n=284) and control (n=343) groups.	Greater decreases in the prevalence of three postural stressors in the experimental group than the control group.	Greater decrease in the prevalence of musculoskelatal disorders by both questionnaire and physical exam in experimental group subjects under 40 years of age than in the control group.

TABLE VI–11.—SUMMARY OF SCIENTIFIC STUDIES DESIGNED TO ASSESS THE EFFECTIVENESS OF ERGONOMIC INTERVENTIONS—Continued

Study	Population	Intervention	Analytic method	Exposure outcome	Health effects outcome
Cook (1999) Ex. 38–205.	20 meatpackers	Clamp rather than hand to hold hog head while chiseling. Modified handle and tool balance for ham trimming, Air knife to cut casings rather than pulling casings by hand.	RMS EMG measurements if biceps, extrinsic finger and wrist flexor muscles after calibration. Workers randomized order of trials between old and new method by each worker for 30 minutes (multiple A–B–A–B research design).	Left wrist and finger flexor muscle effort was significantly reduced in chiseling operation (hand holding eliminated). Right wrist and finger flexor muscle effort significantly reduced in ham trimming. Casing pulling task showed no significant reduction in muscle effort.	
Drury & Wick (1984) Ex. 26–1244; Wick (1987) Ex. 26–1058.	Shoe manufacturing workers.	Ergonomics program including employee training and involvement in developing controls, systematic process of task analysis, design, testing, implementation and measurement. Tilted work surfaces, arm & foot rests, adjustable chair, pneumatic pedal, pallet leveller.	Pre-post study design. Observational analysis of posture, force, frequency every half hour for week pre and post intervention, postural discomfort survey, performance measures Data for 5 jobs presented.	Prototype implementation showed productivity increased or remained unchanged, awkward wrist motions decreased, postural stress ratings decreased.	Body area discomfort eliminated (except forearm). Two year follow-up of ornament job (Wick) showed no additional injuries reported.
Evanoff (1999) Ex. 38–32.	100–110 orderlies in a 1,200 bed urban hospital.	Used a participatory worker-management ergonomics committee to design and implement changes in training and work practices for lifting.	Two year longitudinal evaluation of pre and post intervention injury rates and self reports of symptoms.	Not reported	Decreased OSHA recordable injury and lost workday rates (relative risk = 0.64 for all injuries and 0.4 for lost time injuries among orderlies, adjusted for rates among other hospital staff. Statistically significant reductions in reports of various systems.
Garg (1999)	Seven nursing homes and one hospital, employing 57–136 nursing personnel each.	Used Participatory employee-management advisory teams to implement ‘‘zero-lift programs’’.	One year longitudinal comparison of pre and post intervention injury statistics.	Not reported	For injuries from patient transfers: 62% decrease in the number of injuries, 86% decrease in lost workdays, 64% decrease in restricted workdays, 84% decrease in workers' compensation costs.

TABLE VI–11.—SUMMARY OF SCIENTIFIC STUDIES DESIGNED TO ASSESS THE EFFECTIVENESS OF ERGONOMIC INTERVENTIONS—Continued

Study	Population	Intervention	Analytic method	Exposure outcome	Health effects outcome
Garg & Owen (1992) Ex.–1093 (1994) Ex. 502–481; Owen & Garg (1994) Ex. 26–1415.	57 nursing assistants in 2 nursing home units.	Walking belts and mechanical hoists, shower chairs.	Pre-post study design: observed transfer techniques, rate of perceived exertion, OSHA 200 logs 4 years prior to intervention and 4 months post intervention.	Significant reduced perceived exertion with mechanical and belt transfers compared to manual transfers. Mechanical lifts with scales and shower chairs reduced the number of transfers required per patient.	Back injury incidence rate decreased from 83 to 42 per 100 FTEs, Severity rate decreased from 634 days to 0 days per 100 FTEs [Note: short follow-up time reduces strength of the study. There was an increased in injury/severity rate in the first phase of the intervention on one unit, but none of thee injuries were related to resident transfers]
Harms-Ringdahl Ex. 26–630.	71 Electronic circuit board assembly workers.	Suspended arms support to reduce neck and shoulder muscle static loading.	Pre-post intervention design. Symptoms (VAS) 12 months and one week prior to intervention, and 3 months (n=31) and monthly ratings for 1.5 years post intervention (n=71).	Not reported	31 subjects per-3 months post shoulder symptoms decreased from 62% to 45%, for neck decreased from 57% to 55%. Mean end of shift VAS in 1.5 year follow-up decreased from 46mm to 24mm, and for neck 41mm to 19mm. 93% of subjects using the balancers after 1.5 years. [Note: paired analysis was not used at 1.5 years].
Jones (1997) Ex. 32–339–1–29.	12,000 employees in 13 poultry processing plants.	Comprehensive corporate-wide ergonomics program, including management commitment, ergonomic committees, risk factor checklists, job analysis, medical management, education and training, and job modification.	Five year longitudinal evaluation of workers' compensation rates and costs and overall program assessment scores..	Not reported	46% and 20% decrease in UEMSD incidence rate and severity rate, respectively. 50% and 36% decrease in lifting claims incidence rate and severity rate respectively.
Kadefors (1996)	Auto assembly workers in the assembly versus parallel assembly.	Increase task variability, increase cycle time, increase standing upright.	Comparsion of factories with and without parallel assembly and tilting car capacity using observational analysis and EMG.	Reduced time in awkward postures in each assembly step when using tilting device, lower muscle load with tilt assembly, reduced discomfort.	Not described; small sample size in pre-full production phase limits conclusions.
Loisel, (1997) Ex. 38–28.	130 employees from various workplaces, absent from work for more than four weeks with back pain.	Either occupational (including ergonomic) or clinical intervention, separately and in combination.	Population based randomized clinical trail with three intervention groups and one control group.	Not reported	The occupational and the combined intervention groups returned to regular work 1.5 and 2.4 times faster than those in the usual care intervention group or the clinical intervention group.

TABLE VI–11.—SUMMARY OF SCIENTIFIC STUDIES DESIGNED TO ASSESS THE EFFECTIVENESS OF ERGONOMIC INTERVENTIONS—Continued

Study	Population	Intervention	Analytic method	Exposure outcome	Health effects outcome
Marklin & Wilzbacker (1999).	Electric utility warehouse workers.	(a) Raise location of heavy objects from below knee to thigh height. (b) Replace heavy oak gate with lighter pine gate. (c) Modify tool with extension and better drill bit. (d) Maintenance of pulling system. (e) Height adjustable lift table for handling meter readers. (f) Semiautomated pallet wrap machine. (g) Power tool for opening line clamps.	Pre-post intervention assessment of exposure in jobs with historically high injury rates using NIOSH lifting equation, 3D Static Strength Prediction Program, Lumbar Motion Monitor and Perceived Exertion.	Reduced lifting index (a&b), Increased percentage of population capable (c & d), Reduction in probability of back injury reduced (e & f), Reduction in perceived exertion (g).	Not reported.
McKenzie (1985)	6,600 Telecommunications manufacturing workers.	Ergonomics program with taskforce, training for engineers and supervisors, improved workstation and tools, medical management of restricted workers.	Pre-post program design using OSHA 200 logs for repetitive trauma disorder cases, lost and restricted days. Program was implemented in 1981.	Not reported	Dramatic decrease in number of cases, lost and restricted days. Authors attribute much of the improvement in lost and restricted days to better medical management.
Melhorn (1996) Ex. 38–19.	212 rivet gun employees.	Random assignment to various combinations of posture training, exercise training and rivet gun types.	Longitudinal evaluation of risk factors among eight exposure groups compared with controls.	Decreased risk associated with ergonomic posture training. Vibration dampening rivet guns associated with decreased risk among new hires and increased risk among previous hires.	Not assessed.
Melhorn (1999) Ex. 38–131.	3152 newly hired sheet metal mechanics.	Comprehensive program of education, job placement, modifications and medical management designed for employees based on individualized risk assessments.	Prospective cohort evaluation with pre and post intervention comparisons.	Not reported.	Increased recordable case incident rate and hours worked per employee. Decreased lost time case incident rate, lost time severity rate, and workers' compensation costs per employee. Benefit to cost ratio of 16.5/1.0.
Meyers *et al.*(1999)	194 Wine grape harvest workers in 3 vineyards.	Substitute smaller tubs to lower weight to below 50 pounds.	Participatory ergonomics intervention study addressing load weight and hand coupling. Used checklist to identify tasks and lumbar motion monitor and NIOSH Lifting Equation to assess physical load, symptoms questionnaires and OSHA logs to assess health.	Reduced tub weight from 57 to 47 pounds.	Results not reported.

TABLE VI–11.—SUMMARY OF SCIENTIFIC STUDIES DESIGNED TO ASSESS THE EFFECTIVENESS OF ERGONOMIC INTERVENTIONS—Continued

Study	Population	Intervention	Analytic method	Exposure outcome	Health effects outcome
Miller (1971) Ex. 26–1250.	Surgeons and scrub nurses.	Added larger surface area to handle of surgical forceps to increase stability and decrease load on fingers.	Pre-post testing of extensors and flexors with EMG over 35 procedures by six surgeons.	Reduced fatigue and required recovery time.	Not applicable.
Moore (1994) Ex. 38–339–1–35.	5 engine assembly workers.	Participatory ergonomics approach: eliminate carrying 11.6–14.7 kg parts, eliminate high impact use of brass head hammers.	Pre-post case study of one job. OSHA 200 log incidence data (39 months pre, 30 months post), Borg scale, satisfaction, psychological demands.	Carrying tasks not full eliminated, manual hammering eliminated Reduction in RPE.	UECTD Incidence rate decreased 78%, 82% decrease in restricted or lost day rates.
Moore & Garg, (1996) Ex. 38–24; Moore & Garg, (1997) Ex. 26–21.	930 pork slaughtering plant employees.	Two departmental ergonomics teams used to analyze jobs and develop ergonomics interventions.	Quasi-experimental design, using post intervention comparisons of non-equivalent groups.	Exertions per minute, hand/wrist posture and strain index scores improved for leaf lard pulling job. Biomechanical stresses to the low-back, shoulders and guts hand eliminated on gut snatch job. Percent exertion per cycle, exertions per minute, and hand/wrist postures improved on rib pull job.	Not assessed.
Parenmark (1993)	Tool and Equipment manufacturing.	Engineering and organizational improvements in design of new factory: adjustable work heights, work technique training, job enlargement, work pace decrease 25%, work organization, flexible work hours, wage system, rehabilitation.	Pre-post design. Follow-up 18 months after production started in new factory, emg biofeedback to keep load below 15–20% MVC. Sick leave and turnover rate were outcome measures.	Not reported.	Sick leave decreased 5%. Turnover decreased 25%.
Rooney *et al.*(1992) Ex. 26–1056.	400 shoe and canvas luggage manufacturing employees.	Total quality management program, using an ergonomics team ''to closely follow the proposed OSHA ergonomics guidelines''.	Pre and post intervention job analysis.	373 job modifications, 85 of which achieved more than 25% reduction in force, repetition or postural stress.	Annual lost time incident rate reduced from 14.9 to 3.3 per 200,000 hours during four-year study period. Not analyzed for specific associations with job modifications.
Rosecrance & Cook (2000) Ex. 38–253.	455 Newspaper employees.	Continuous improvement process, using an ergonomics committee to manage a five step problem solving method.	Pre and post intervention questionnaires and non-structured interviews.	At least one intervention completed in eleven of twelve office and production areas, including engineering and administrative changes to problem jobs with static postures, repetitive tasks and non-adjustable workstations.	Not assessed at 4–6 months post intervention.

TABLE VI–11.—SUMMARY OF SCIENTIFIC STUDIES DESIGNED TO ASSESS THE EFFECTIVENESS OF ERGONOMIC INTERVENTIONS—Continued

Study	Population	Intervention	Analytic method	Exposure outcome	Health effects outcome
St. Vincent (1998) Ex. 500–71–64.	2 electrical product manufacturing plants.	Participatory ergonomics process: 7 jobs with 50 solutions implemented: improving material feed, repositioning of materials, change in work station dimensions, change in product jigs, tool changes, job enlargement, handling aids.	Pre-post design. Video analysis of posture, force, duration, frequency, impacts.	78% of solutions reduced risk factors (postural load, forces applied), 14% had no observable effect, 8% could not be evaluated.	Not reported.
Shi (1993) Ex. 26–1099.	County government workers.	One year Back injury prevention program: Individual health risk assessment at year 1 and year 2 in intervention group (fitness, job demands, satisfaction, demographics), training, ergonomic improvements (lifting devices, gait belts, improved seating, minimizing transport).	Pre-post randomized intervention groups (n=4, 77% participation) and control groups (2) with similar demographics. Measures: Satisfaction, HRA scores, symptoms prevalence, workers compensation rates.	Not reported	Nonsignificant frequent back pain prevalence decreased in intervention groups whereas overall prevalence significantly decreased. Significant increase in job satisfaction. Significant decrease in HRA risk status (not recorded for control groups). WC costs per claim increased in control groups but decreased in all intervention groups. Return on investment =179%. Participants believed ergonomic interventions contributed the most. No attempt to separate effects of ergonomics improvements from individual health promotion behavior in design or analysis.

Three individual studies are particularly persuasive (Melhorn *et al.*1999, Loisel *et al.*1997, Brisson *et al.* 1999). Melhorn *et al.* (1999) reported the results of a 5-step MSD prevention program based on OSHA and NIOSH ergonomics guidelines and implemented in a large aircraft manufacturing facility. This comprehensive program included education, risk factor analysis, job placement (including transitional (or ''restricted'') work), job modifications and medical management designed for employees based on individualized risk assessments. The authors followed a group of 3,152 newly hired sheet metal mechanics, using a prospective cohort design with pre-and post-intervention comparisons. Potential confounders considered included hours worked per employee, average number of employees and new hires, and rates in otherwise comparable plants without programs. The authors compared outcome data for several years pre- and post-program implementation. Although the recordable case incidence rate and the hours worked per employee increased moderately in the period studied, there was a substantial decrease in the lost time case incident rate, lost time severity rate, and workers' compensation costs per employee. Workers' compensation costs did not decrease in comparison facilities during the study. The authors reported a benefit to cost ratio of 16.5/1.0 for this program.

Brisson *et al.* (1999) conducted a longitudinal comparison of postural stressors and injuries in randomly assigned experimental (n=284) and control (n=343) groups of university employees keying five or more hours per week at a video display unit. The experimental group received ergonomic training in the identification of postural stressors and in making changes in equipment and work activities. Measurements were taken two weeks prior and six months post intervention. Symptoms questionnaires and standardized physical examinations were used to assess health effects, controlling for individual and lifestyle factors. Observational analysis was used to assess risk factor reductions. There were significantly greater decreases in the prevalence of three postural stressors (twisted neck, height of visual target, broken hand-wrist line) in the experimental group after the training than in the control group. There was also a greater decrease in the prevalence of musculoskeletal disorders as reported both in questionnaires and in physical examinations in the experimental group subjects under 40 years of age than in the control group. Symptom prevalence decreased from 29% to 13% in the experimental group for those less than 40 years of age. The prevalence of physical findings decreased from 18.8% to 2.9% for those under 40 in the experimental group compared to a decrease from 18.3 to 10.8% in the reference group. There were no significant differences between the experimental and control groups in hours of VDU use, psychosocial work factors, smoking, leisure time, or body mass index. The differences between the younger and older workers appeared to be related to the duration of symptoms with older workers having longer duration.

Loisel *et al.* (1997) used a population-based, randomized clinical trial design to evaluate 4 return-to work (RTW) approaches for workers with acute back problems who were absent from work for more than 4 weeks. These included occupational intervention (including ergonomics), clinical intervention, combined intervention or usual care. One hundred thirty employees from 40 different workplaces were followed for 1 year. Survival analysis was used to estimate return to work time. The occupational (ergonomics) intervention group and the combined intervention group returned to work 1.5 and 2.4 times faster, respectively, than the usual care group or the clinical intervention group.

OSHA finds that this additional body of scientific intervention studies, taken together with the other data presented in the preliminary-final risk assessments, provides strong evidence that ergonomics programs are effective in reducing MSD risks to workers. These studies have documented that reductions in exposure to biomechanical risk factors, as well as reductions in the rates of MSD cases and symptoms, follow implementation of ergonomic interventions. These findings are consistent with the epidemiological and biomechanical evidence presented in the Health Effects section that demonstrate the role of biomechanical risk factors in the development of MSDs.

OSHA also examined two recent reviews (Linton and Van Tulder, 2000, and Lincoln *et al.,* 2000) that concluded that the intervention literature provides little or no evidence of the effectiveness of ergonomics programs. OSHA finds these reviews unconvincing for the following reasons:

Linton and Van Tulder (2000, Attachment to Ex. 500–118) identified 900 articles about the prevention of musculoskeletal problems. They then restricted their evaluation to 20 studies of randomized controlled trial design and 8 studies of non-randomized trial design, each of which was designed to study ways of preventing long-term neck or back problems in subjects not seeking treatment; the methods used in these studies included back school training, exercise programs, etc. None of the studies involved workstation modifications, changes in controls or work practices, or administrative controls. Not surprisingly, the authors concluded that there is no evidence of good quality on the effectiveness of ergonomics interventions. OSHA gives this study little weight because the authors made an arbitrary decision that studies have no validity unless they are ‘‘controlled trials’’ (the authors do not define the term). The authors also exclude from consideration any studies of upper or lower extremity problems and any studies involving subjects who sought treatment. Their sweeping conclusion goes far beyond what is supportable, based on the very small group of 28 studies that meet their inclusion criteria.

Lincoln *et al.* 2000 [Ex. 500–118nn] assessed the intervention literature related to work-related carpal tunnel syndrome (CTS). Twenty-four studies met their inclusion criteria, which included having a comparison group; implementing engineering, administrative, personal or multiple component interventions; and describing outcome measures related to CTS or upper extremity MSDs. Although these authors found that multiple component programs were suggestive of positive effect, the authors concluded that lack of randomization and lack of control for confounding weakened the conclusions to be drawn from these studies. OSHA does not agree that this conclusion undermines the findings drawn from the many intervention studies reviewed by OSHA. As noted above, randomization of engineering controls in intervention studies is particularly problematic because very few employers are willing to permit investigators to dictate which employee groups receive different types of job interventions, or no intervention at all. Small sample sizes continue to limit research in this area as technology and markets change to more flexible niche market demands and as there is an increase in temporary workers limiting long-term follow-up of outcomes. This real-world phenomenon is not unique to the study of work-related musculoskeletal disorders. Frank *et al.*1996 [Ex. 38–207] pointed out that most of the study design factors that produce the most convincing evidence are outside the control of the researchers in occupational settings; such design factors include stable working populations and processes; randomization of intervention groups; and the need for long-term follow-up, which is made difficult during economic downturns, product or process changes, or during labor-management problems. In most cases, quasi-experimental designs, such as those reviewed by OSHA in Table VI–10, which use either concurrent comparison groups or historical control groups, present the best available evidence of the effectiveness of engineering or administrative controls in reducing occupational risks (Zwerling *et al.*, 1997, Ex. 500–71–65, Goldenhar & Shulte, 1994, Ex. 26–126). OSHA discusses the need for and use of randomized or controlled clinical trials in ergonomics research later in this section in response to comments that were made to the record.

In addition to the scientific studies, the record contains a large number of case reports documenting the experiences of employers and occupational health professionals who have implemented ergonomics programs. OSHA reviewed several of these in its preliminary risk assessment; however, since publication of the proposal, many additional case reports have become available. Generally, these reports, which are listed in Appendix VI–B, involve case studies of individual companies that have instituted programs that include some or all of the elements of the ergonomics program required by the standard; these reports describe the results of ergonomic interventions in a wide variety of industry sectors, including manufacturing establishments, service establishments, health care facilities, as well as in other workplaces where jobs routinely involve manual handling. Overall, OSHA identified over 300 case studies that quantified the reduction in MSD incidence following implementation of ergonomic programs and interventions; of these, 262 provided data on the reduction in MSD numbers or rates. From these studies, OSHA's measure of intervention effectiveness is based on 226 values for the reduction in total (*i.e.*, lost workday and non-lost workday) injuries and illnesses, and 81 values for lost workday injuries and illnesses. These case studies do not reflect a ''quasi-experimental'' study design because they do not use control groups and there is generally no evaluation of workplace exposures by an independent investigator; instead, a company's or establishment's MSD rate experience is evaluated before and after implementation of an ergonomics program or intervention. Thus, the outcome measure used in these studies reflects the measure that is probably most often used by employers who wish to evaluate whether their programs are effective. Documenting changes in MSD rates before and after implementation of an ergonomics program is, in fact, one of the methods listed in the final rule by which employers may evaluate the effectiveness of their ergonomics programs.

To characterize the experiences of employers and safety and health professionals in implementing these programs, OSHA determined the range, median, and mean reduction in MSD case rates for the overall data set, using the same approach as was used in the preliminary risk assessment. From each of these case studies, OSHA calculated the effectiveness of the standard (*e.g.*, employee involvement and training, implementation of engineering or work practice controls). These case studies of ergonomic interventions measure effectiveness as the percent reduction in either lost workday or total number of MSDs prior to and after implementation of the program. That is, effectiveness was calculated as the ratio

$$\left(N_B - N_A\right)/N_B$$

where N_B represents the number or incidence of MSD cases prior to implementation of the ergonomic intervention, and N_A represents the number or incidence after the intervention[1].

OSHA's estimate of the overall effectiveness of ergonomics programs is expressed as the median and mean reduction in MSD injury rates contained in this data set; Appendix VI–3 to this section tabulates OSHA's effectiveness measure for each of the case studies that provided quantitative data, and also shows the time interval over which the change in injury rate was measured. For all MSDs (*i.e.*, lost workday and non-lost workday MSDs), these case studies reported a median 67-percent reduction in injury rates (mean effectiveness was 64 percent). The median and mean reductions for lost workday MSDs only were somewhat higher, at 75 percent and 71 percent, respectively. Although the effectiveness of individual ergonomics programs varied widely among the establishments described in these case studies, most interventions (about 87 percent of the case studies) achieved at least a 30 percent reduction in MSD injury rates, 61 percent of the case studies reduced MSD rates by half or more, and several achieved the total elimination of lost workday MSDs (see Appendix VI–B).

E. OSHA's Response to Comments on the Program Effectiveness Evidence

Gibson, Dunn & Crutcher (Exs. 32–241–4, 500–197) raised several issues regarding OSHA's analysis in the proposed rule of the effectiveness of ergonomics programs. These issues were

- The lack of evidence that ergonomic interventions will reduce low back pain, as evidenced by a comprehensive literature evaluation conducted to develop the Agency for Health Care Policy and Research (AHCPR) medical guidelines for acute low back pain;
- The necessity of conducting randomized controlled trials to determine whether ergonomics programs will, in fact, be effective;
- OSHA's reliance on the epidemiological data in making inferences about the effectiveness of ergonomics programs; and
- Criticisms of individual case studies relied upon by OSHA to demonstrate program effectiveness.

In their post-hearing comments, from Gibson, Dunn & Crutcher (Ex. 500–118) stated that ''After conducting an exhaustive study, Dr. Bigos' panel, under the auspices of the AHCPR, 'failed to find evidentiary support for the use of ergonomic interventions to treat back pain injury complaints.' '' However, in the Executive Summary for the AHCPR low back pain guidelines, the purpose of the effort was clarified as follows: ''The Agency for Health Care Policy and Research (AHCPR) convened a 23-member, multidisciplinary, private-sector panel to develop a guideline for the *evaluation* and *treatment* of acute low back problems in adults.'' (Emphasis added)

Under the section entitled Scope and Organization, the following statement occurs: ''This Clinical Practice Guideline is intended to provide primary care clinicians with information and recommended strategies for the assessment and treatment of acute low back problems in adults.'' The word ''ergonomic'' appears four times. Twice, this term is used to describe back school programs included in the analysis. One citation simply points to a review of safe lifting. The final citation notes: ''Several ergonomic guidelines on lifting and materials-handling tasks are available to help the clinician provide ranges of activity alterations at work.'' Thus even the AHCPR panel felt it beneficial to employ ergonomic guidelines on lifting and materials handling in establishing safe levels of work activity for patients with acute low back pain. The section on prevention consists of a total of two paragraphs and 195 words, including a just three citations, two of which are opinion papers rather than research studies. Therefore, the published AHCPR low back pain guidelines do not, and do not purport to, have a focus on non-acute low back pain, work-related low back pain, ergonomics or prevention of low back pain. Citing the AHCPR guidlines as evidence that ergonomics interventions are not effective in reducing the risk of low back disorders is inconsistent with the cited purpose and scope of the document itself. Therefore, OSHA is not persuaded by this argument that the guidelines ''failed to find evidentiary support for the use of ergomonic intervention to treat back pain injury complaints;'' indeed, they would hardly have done so because they did not look for such evidence.

Regarding the second issue, Gibson, Dunn & Crutcher (Exs. 32–241–4, 500–197) asserted that randomized controlled trials (RCT) and controlled clinical trials (CCT) are the only study designs that can demonstrate whether ergonomics interventions are effective. They stated that:

> The fact that there is no RCT supporting the proposed standard is a major weakness in OSHA's position * * *. [W]ithout RCT, OSHA cannot show that the alleged risks at issue will be alleviated by particular solutions contained in its proposed rule. [Ex. 500–197, pp. I–104 to I–105]

They also quote the statements of two of their witnesses, Dr. Bigos and Dr. Fisher. Dr. Stanley Bigos, Orthopedic Surgeon and Professor in the University of Washington Department of Orthopaedics, called prospective RCTs:

[1] Note that, by this definition, the presence of background MSD cases (non-work-related cases) will decrease the apparent effectiveness of ergonomic interventions since the interventions would presumably not have any effect on the background rate of MSDs in the working population (*i.e.*, both N_B and N_A might contain background MSD cases).

* * * the gold standard for evaluating the efficacy of interventions in medicine. * * * This is a widely accepted standard across medicine, and across science. * * * The strength of the RCT is that both known and unknown risk factors are balanced across treatment groups, so that any differences in outcomes are more likely to be attributable to specific interventions (Ex. 500–197, pg. I–104).

Dr. Lloyd Fisher, Professor Emeritus in the Department of Biostatistics, University of Washington, likewise claimed that because there have been no RCTs on interventions in ergonomics, ''We have no evidence that these rules are going to work. They might work. They might be harmful.'' (Fisher Tr. 6740). A third witness, Dr. Shekelle, stated:

To my knowledge there is not a single well conducted randomized clinical trial of any intervention designed to modify any of the ergonomic factors proposed in the OSHA document that has proven to have a beneficial effect on disability due to back pain. (Ex. 500–197, pg. I–104).

Controlled clinical trials are used principally in medicine to test the efficacy of alternative treatments on patients. In a typical design, one group of patients that has been diagnosed with a specific disease or disorder is given the usual medical care and one or more other groups of patients with the same disease or disorder are given alternative treatments. The response of the test group(s) to the new treatment is compared with the response in the control group to determine whether the new treatment(s) were more or less effective than the standard for treatment. In a randomized trial design, the patients are randomly assigned to the various test or control groups; in a controlled, non-randomized clinical trial, assignment of patients to the various groups is not made using a purely randomized procedure. The randomized trial is considered overall to be the superior design since it has the greatest likelihood of controlling for both known and unknown confounders, increasing the ability to attribute any observed differences in treatment responses between the groups to the treatments themselves.

OSHA has carefully considered these comments that RCT studies in ergonomics are necessary to determine the effectiveness of interventions in reducing risk (and the related argument that such a high standard of scientific evidence is necessary before prevention procedures should be required). Although the Agency agrees with Dr. Bigos that RCT and CCT are the appropriate statistical designs for trials on the safety and efficacy of pharmaceuticals, or for a comparison of the effectiveness of different treatments for diseases and medical conditions, the study of interventions in ergonomics covers many more and different factors. Thus, any ergonomics RCT or CCT would require far more complex statistical designsand require many more subjects. Another major difference is that intervention studies, unlike typical medical or pharmaceutical efficacy studies, would start with healthy groups and then test for differences in subsequent risk or incidence of MSD. A pharmaceutical study equivalent, for example, would be a trial to test a drug that would prevent a specific cancer or chronic disease, not just treat it. Such medical RCT prevention trials would require a less complex statistical design than a good ergonomic intervention, *i.e.,* prevention, study; yet even are such a trial would be prohibitively expensive when the disease incidence is fairly low, (because many subjects would be required), and this expense would increase as the required follow-up time and effort increased.

As an example of the expense of an RCT ergonomic study, Dr. Frank, considering a simpler prospective design than required would be required for an ergonomic intervention study, in his testimony related his attempt to study physical loads on the back as an independent risk factor for workplace lower back pain, controlling for several individual characteristics of the worker:

And in a nutshell, we decided that the key thing was, and it is very expensive to do this, to actually measure the physical loads on the back. * * * It costs us about $2,000 U.S. dollars per subject. And we did well over 300 subjects to simply use a case-control design (emphasis added). * * * you cannot afford to do those measurements on the 5,000 workers, give or take a few thousand that you need to follow if you are going to use a cohort or prospective design to see who subsequently develops back pain (Tr. 1341).

In addition to the expense of RCT intervention studies, conducting such studies over a period of time sufficient to make valid conclusions, often means that unforeseen changes in conditions occur, invalidating the original study design. This is especially true when dealing which are often characterized by workplaces with changing conditions and workers who can self select on job or life style condition changes. For these reasons, and also because the number of industry sectors and variety of work conditions is so large, the results from the few carefully designed ergonomic RCTs that could be conducted over the next 5 to 10 years would be difficult to generalize to U.S. industry as a whole.

For all of these reasons, OSHA believes that sufficient RCT intervention studies could not be practically conducted within a reasonable time frame to justify delaying regulatory action. Therefore, OSHA disagrees with the arguments of the Coalition and its witnesses that OSHA should wait to issue its final rule until RCT studies can be conducted.

In estimating risk and risk reduction in this section, OSHA, as it has in all of its past rulemaking efforts, relies on the well-founded public health concept that, if risk factors can be identified that contribute to the etiology of disease, it is reasonable to act to reduce exposure to those risk factors to reduce the risk of disease. OSHA's logic and rationale in this rulemaking are similar to the position taken by Dr. John Frank, Professor, Public Health Sciences, University of Toronto (Ex. 500–64). Under the heading ''Standard Public Health Practice Regarding Hazard Control'', Dr. Frank poisted three conditions as the basis for deciding whether to implement ergonomic abatement policies:

- ''Is there 'reasonable cause' * * * to believe that exposure to the putative hazard truly does lead to measurable adverse health effects?'';
- ''Is there reasonable cause to believe that feasible hazard abatement/control intervention * * * *e.g.* ergonomic job modification/design * * * actually reduce exposure to the hazard?'' and
- ''Is there reasonable cause to believe that no significant harmful consequences of implementing such an intervention will occur * * *?'' (Ex. 500–64)

Regarding the first question, whether the evidence supports causal association between exposure to the hazard and workplace MSDs, OSHA has concluded in its Health Effects section (Section V) that there is substantial evidence that exposure to biomechanical risk factors at work—repetitive motion, forceful exertion such as heavy lifting, non-neutral body postures, contact stress, and segmental vibration—all contribute to the risk of MSDs. OSHA has followed the weight-of-evidence approach for evaluating the best available body of scientific evidence on ergonomics, especially the large amount of epidemiologic data, and finds that the evidence, as judged by the (Sir Austin Bradford) Hill criteria, used by the scientific community for over forty years, is convincing. Like Dr. Frank, OSHA especially notes the consistency in findings across epidemiologic studies and the consistency between the epidemiological studies and the accumulated scientific knowledge on biomechanics and tissue pathology that provide mechanistic explanations of the etiology of work-related MSDs. This body of evidence is also coherent in terms respect to temporality, *i.e.,* to the cause and effect timing and to the populations in which the effects are most frequent or severe. The Health Effects section (Section V) also contains sufficient evidence on exposure-response to further confirm these findings.

Dr. Laura Punnett, an epidemiologist and ergonomist, and member of the panel that reviewed the epidemiologic evidence on work-related MSD for the National Academy of Sciences, agrees with OSHA's findings:

> In summary, the epidemiologic evidence that links physical and ergonomic exposures at work with the risk of MSD is extensive and includes a sufficient number of methodologically strong studies to [implement] primary prevention activities. In the light of the experimental literature, the epidemiology is certainly most plausibly interpreted [as] showing a causal effect of occupational physical stressors on MSD among people with exposures on the job (Punnett, Tr. 874).

Having found that MSDs are causally related to multiple biomechanical risk factors, OSHA rejects the arguments of the commenters that OSHA should conduct RCTs in order to determine whether or which specific interventions will reduce MSD risk. OSHA believes that other types of approaches can be used; in particular, OSHA believes that the analogy between ergonomice interventions to address the multifactoral nature of ergonomic risk factors and interventions for the multiple risk factors associated with the development of coronary heart disease (CHD, *e.g.,* blood pressure, weight, smoking, and cholesterol) is appropriate. For CHD, risks and risk reductions were estimated for these factors long before there were any results from controlled prospective trials (Frank, Tr. 1340). OSHA notes the post-hearing comments of Anheuser-Busch Inc. and United Parcel Service Inc. comparison which included Dr. Michael Vender's and Dr. Arthur Barsky's objections to Dr. Frank's of CHD and back pain. Dr. Vender states that, unlike coronary heart disease, back pain is ''a subjective experience and can originate from many sources that are not readily identified or measurable, including muscle, ligament, joint and disc.'' (Ex. 500–118, Tab Kn pg. 21). OSHA finds Dr. Vender's argument irrelevant, however, since the relevant connection in Dr. Frank's analogy is that in the case of CHD the medical and public health communities implemented interventions to lower CHD risk factors that had been identified through study designs that were not RCT, rather than waiting to intervene until RCT studies had been conducted.

OSHA next considers the second question posed by Dr. Frank, whether there is reasonable cause to believe that feasible hazard abatement and control interventions (*e.g.,* ergonomic job modification/design) will actually reduce exposure to the hazard. As with its other rules, OSHA finds that, having identified specific biomechanical risk factors that contribute to the etiology of MSDs, procedures to reduce exposure to those factors will reduce risks. This is the underlying principle that has goverened all of OSHA's prior health rulemakings, and it is also the principle providing the foundation for public health interventions. Moreover, as the discussion earlier in this part of the Risk Assessment demonstrates, OSHA has accumulated substantial evidence, both scientific in nature and less formal, reflecting employers experiences with ergonomic programs, and showing that ergonomic interventions do reduce exposures to biomechanical risk factors and do reduce the prevalence and incidence of MSDs.

With respect to the types of studies needed to estimate risk and risk reduction, OSHA notes that potential risk reduction is estimated in many of the Agency's past rules by extrapolation of study results using mathematical dose-response models. None of these risk and risk reduction estimations relied on RCT. Several of these estimates were derived from modeling studies with retrospective cohort designs. In these studies, it was common in the course of the cohort's time frame that ''interventions'' occurred, in the industrial hygiene sense, to reduce exposures to the putative chemical agent. However, in these studies information about the exact interventions or exactly which cohort members these interventions affected is usually very limited, and the studies could hardly be considered ''controlled.'' Furthermore, all estimates for risk reduction required extrapolation beyond the range of observation, for which there were no ''interventions.'' This methodology is based on the logical rationale that if causes or risk factors for adverse health effects are established, a reduction in exposures to these factors will lead to a reduction in the adverse effects.

With regard to Dr. Frank's third question, whether there is reasonable cause to believe that no significant harmful consequences of implementing such an intervention will occur, OSHA has found no evidence in the record that implementation of ergonomic programs will harm employees; several of the scientific witnesses testifying on behalf of the UPS and others raised this possibility (Exs. 32–241–3–4), claiming that ergonomic interventions will result in deconditioning of the workforce and a resulting increase in the risk of MSDs. OSHA discussed this issue in detail in the Health Effects section (Section V of the preamble) and rejected this argument. In brief, OSHA finds that its final ergonomics program standard is consistent with current medical practice and guidelines, will not encourage an unhealthy level of inactivity in lieu of returning to a safe level of work following an injury, and is therefore unlikely to harm workers by discouraging conditioning.

Finally, several commenters presented arguments that it would be unethical to withhold interventions. The ethical arguments was summarized by Dr. Frank:

> There is also the moral impropriety of randomizing [for RCT studies] a set of communities or set of workplaces to not have a putative hazard abated (Ex. 500–64).

Dr. Punnett also testified that controlled trials are inappropriate in the context of protecting the public from exposures to hazardous agents. When asked whether controlled trials are the only scientifically rigorous method for determining causal relationships between exposure to risk factors and the risk of MSDs, she replied:

> You know, I really find that quite an extraordinary concept. * * * I could hardly imagine that OSHA would have ever been held to putting subjects in an exposure chamber and exposing them to coke emissions or benzene vapors or cotton dust to see whether they developed cancer or lung disease. And the whole idea that this would be the kind of evidence that would need to be provided in order for OSHA to take preventive action, truly it is astounding to me. And there are lots of examples. I mean, I showed international criteria documents, the European Union taking action on physical ergonomic exposures without ever a mention of such a thing as a randomized clinical trial in this area. [Tr. 1001–1002]

OSHA considers this ethical argument to be valid in that the Agency does not desire to delay hazard abatement in order to conduct an RCT, the result of which may or may not be generalized to worker populations overall. This is especially the case because the Agency already has a sound methodology for measuring the extent of current risk and the potential that reduction in risk associated with implementation of the standard.

Gibson, Dunn & Crutcher in their post hearing comments criticized OSHA for using epidemiology studies to assess the work-relatedness of MSDs and as a source of information and data to estimate the effectiveness of ergonomics programs (Ex. 500–118, pp. II–25 to II–36). Part of Gibson, Dunn & Crutcher's criticism relates to their claim that ''a statistical level of 'risk association' from an epidemiologic study cannot translate into a measure of effectiveness for OSHA's proposed program.'' (Ex. 500–118, p. II–27). They provided three reasons to support this claim. First, they claim, even assuming that OSHA's risk ratio estimates for the work-related MSDs are correct (which they do not concede), that by changing the job conditions:

there will still be some level of force or repetition, some movement from completely neutral posture * * * that presumably could cause 'contact stress.' * * * In changing a job to address one 'risk factor,' moreover, an entirely different concern might be created. * * * Yet OSHA's approach would measure the effect as if it were the difference between the ''risk'' from the old job and *zero.* That assumption is simply wrong. (id. II–29).

Second, they claim that '' 'deconditioning' from a reduction in physical activity may play a very significant role in increasing the risk of MSDs. * * * An epidemiologic study that focuses solely on alleged 'risk factors' in the existing job, however, provides no mechanism for taking this into account, or any other change in the nature of a job as altered after an intervention.'' (Ex. 500–118, p. II–29). The third reason is that ''the 'risk ratios' yielded by epidemiologic studies control only for factors that each author was able to identify and analyze. * * * In the real world, * * * [with many other factors to be considered] the 'risk ratios' attributable to job factors, after fully accounting for all these other variables, would be far lower than those reflected in the epidemiologic evidence.'' (Ex. 500–118, p. II–30). OSHA notes that all of the ''real world'' complications pointed to by these commenters are also pertinent to RCF.

OSHA disagrees with all three of Gibson, Crutcher & Dunn's arguments that ergonomic risk factor epidemiology studies may not be used for risk reduction estimates. Gibson, Crutcher & Dunn argue that reducing one stress factor will either lead to increased risk due to exposure to another stress factor (reason one), or, contradictorily, lead to increased risk because the body is ''deconditioned'' and, therefore, more susceptible to injury (reason two). OSHA's approach for estimating the potential effectiveness of ergonomics programs, in both the Preliminary and Final Risk Assessments, is to estimate the proportion of disease occurring among workers exposed to risk factors that can actually be attributed to their exposure. This approach does not reflect a risk of ''zero,'' as Gibson, Dunn & Crutcher suggest. Instead, this approach explicitly recognizes that only *some* portion of the disease prevalence observed in a population of exposed workers will be affected by intervening to reduce the hazardous exposure. The risk ratios from epidemiological studies are precisely the kind of data that are used to estimate the attributable fraction of disease in an exposed population (*e.g.,* see Hagberg and Wegman Ex. 26–32). For example, if an epidemiological study reports that the rate of disease in an exposed population is twice as high as that seen in an unexposed population, (*e.g.,* an OR of 4), then the attributable fraction can be estimated to be 0.75, or 75 percent. This means that the rate of disease in the exposed population can be reduced by up to 75 percent in response to an intervention. The actual result achieved in an intervention may be less, depending on the effectiveness of the specific intervention employed. These commenters' third reason is that, because the epidemiology studies are limited and cannot control for enough risk factors, the risk ratio estimates from these studies overstate the risk due to the studied risk factor and cannot be generally applied to intervention risk reduction estimates. However, it is not always the case that study biases lead to an overestimate of the risk. Risk ratio estimates may overestimate or underestimate the true risk, depending on the study design, the interrelationship of the risk factors involved, and the comparison of the exposed and control groups. For example, errors in exposure assessment that arise because of the use of imprecise measures to characterize exposure (such as job title) leads to exposure misclassification, which usually results in an underestimate of risk, or even the observed absence of an association where one actually exists.

Gibson, Crutcher & Dunn further argue that, ''even if the epidemiologic evidence has some application, OSHA's review of it for benefit purposes was fatally flawed.'' (*id.,* pg. II–31). They offer several reasons for this opinion; their primary reason is that OSHA took an unweighted median or mean risk of ''every 'risk ratio' it could find in a NIOSH table, even in situations where the majority of study ratios—all but eight in one case—did not even satisfy measures of statistical significance.''(Ex. 500–118, p. II–33). In short, according to Gibson, Dunn & Crutcher, OSHA agglomerated studies of all qualities and all significance levels, studies measuring different risk factors, using different levels of exposure, and different types of control groups. ''The result, in the end, is a mathematically meaningless number whose content dependes primarily on happenstance.'' (Ex. 500–118, pg. II–33).

OSHA believes that there is a good rationale for applying this methodology to estimate median or mean risk ratios from the epidemiological data base by weighing each risk ratio equally (64 FR 65950–65951, see Table VI–9). OSHA believes that the use of epidemiological data and such unweighted median and mean risk ratio estimates, separately for each body part, using the epidemiological data is fair and appropriate, for several reasons. First, the epidemiological data, which is drawn largely from the 1997 NIOSH review (Ex. 26–1), is an unbiased screened review of the published literature, with the result that only higher quality studies are selected. Second, estimating risk ratios by body part agglomerates studies that reflect similar background rates; this should provide a more even distribution of risk ratio estimates than would be the case if all of the studies were grouped together.

Third, including all risk ratios by body part is reasonable, even though some studies estimated risks for more than one body part and may therefore be included in analyses of more than one body part. Often when more than one body part is included in the same study, the risk estimates are based on different subgroups of workers. In OSHA's final risk assessment any one study is included for each body part only once.

Finally, OSHA addresses the criticism of combining unweighted odds ratios from many different high-quality studies, even though NIOSH may have ranked studies according to their quality criteria. OSHA believes that, in this case, unweighted or equal-weighted means and unweighted medians are appropriate and fair. Most important, this methodology gives the same weight to high-quality studies that show no association as to those that do, instead of focusing on the highest risk estimate. OSHA believes this is fair because the large variety of study designs, work situations, and specific disorders addressed in these studies will be more representative of the varied nature of working conditions across the country. On the other hand, if OSHA were to weight risk ratios by some quality criteria, where the best designed studies are rated the highest, the resulting composite risk estimates would be more reflective of a small number of specific exposure conditions, and thus less representative of the broad mix of workplaces covered in the final rule. Consequently, given OSHA's objective to quantitatively characterize the work-related risk of MSDs and the potential effectiveness of ergonomic interventions, using the best available data, OSHA finds that its approach that makes use of all of the epidemiological data judged by the Agency to be of reasonable quality is preferable to relying only on a small subset of those data.

In both their pre- and post-hearing submissions (Exs. 32–241–4, 500–197), Gibson, Dunn & Crutcher raised several criticisms of some of the specific case studies relied on by OSHA in the preliminary risk assessment (these case studies were summarized in Appendix VI–B of the preamble to the proposed standard, 64 FR 65965–65975). In addressing each of these specific comments below, OSHA first identifies the case study or studies being addressed in the comment, quotes or summarizes the comment, and follows that with a response to the comment.

Group of 24 Case Studies From M. Oxenburgh, Increasing Productivity and Profit Through Health & Safety (Ex. 26–1041).

Comment: Methodology that Dr. Oxenburgh used is biased because he only obtained claims of reported success. ''Oxenburgh confirmed that he was looking to write a book * * * to demonstrate 'the effectiveness * * * from an injury reduction perspective' of ergonomic interventions [citing Tr. 2646]. Having 'made known what [he] was looking for,' [citing Tr. 2647] he obtained only reports of success.'' (Ex. 500–197, p II–10) ''* * * [T]reatise * * * unabashedly describes itself as an assemblage of ergonomic 'success stories' designed 'to make believers' out of management [citing p. 2 of Ex. 26–1041].'' (Ex. 32–241–4, p. 215).

OSHA's Response: The introduction to Dr. Oxenburgh's book was written by Dr. Stover Snook, who used the quoted phrases ''success stories'' and ''to make believers.'' Dr. Oxenburgh actually objected to terms such as ''making believers'' and ''success stories,'' because, as he stated at the hearings, he compiled ''a series of case studies which illustrate the concept of health and safety and productivity running together'' (Tr. 2643, ln. 11–13). Gibson, Dunn & Crutcher criticize Dr. Oxenburgh's publication as part of their argument that the case studies relied on by OSHA (which included some of Dr. Oxenburgh's case studies) are not scientific studies (see Ex. 32–241–4, pp. 10–214). However, in its preamble to the proposed rule, OSHA did not claim that the case studies it relied on represented ''scientific'' studies, but instead simply characterized them as sources of ''* * * data on the success of ergonomics programs and workplace interventions, * * * [which are in turn] supported by data from [other] scientific studies [*i.e.,* epidemiological studies and experimental laboratory studies in the record] indicating the potential for successful ergonomics programs'' (Ex. 28–1, p. IV–4). The 24 case studies from Dr. Oxenburgh's book that OSHA used as a source of effectiveness data provide precisely this kind of information, and OSHA does not find that the absence of a formal study design diminishes the utility of these data in describing the beneficial effects that ergonomic interventions have had on MSD rates in actual workplaces. In fact, real-world effectiveness studies, almost by definition, describe what happens in a particular workplace environment when interventions of the kind required by the standard are put into effect. OSHA did not in the proposal and does not in the final rule claim that these studies do more than report what employers have done and the results they have.

Comment: In his testimony, Dr. Oxenburgh stated that he relied as little as possible on written data (citing Tr. 2648), and preferred to accept what he was told on site by the people involved in implementing and working with the intervention (Exs. 500–197, p. II–11, 32–241–4, p. 215). Dr. Oxenburgh did not use a methodology that involved to verification of his claims (Ex. 500–197, pp. II–11). Oxenburgh was willing to accept employer accounts without independent verification (Ex. 32–241–4, p. 231). Dr. Oxenburgh's sources were health and safety professionals who had much to gain and nothing to lose by making exaggerated claims of benefits (Exs. 32–241–4, p. 231; 500–197, p. II–12).

OSHA's Response: To obtain information from establishments, Dr. Oxenburgh visited facilities to conduct personal interviews and perform inspections of the interventions firsthand (Tr. 2648). Although Dr. Oxenburgh did inspect some documents on the site visits, he sometimes obtained written documentation after the visit ''* * * by which time [plant contacts] would have looked up their information.'' (Tr. 2649) At the informal hearing, Dr. Oxenburgh testified that the information and data he received were reliable:

> I cannot see any reason why they should have told me any lies. They were very open with me. When I was going around a workplace, there were no restrictions placed on me to say, ''Oh, don't talk to the workers,'' or anything like that * * * I have no reason to believe that people were not telling me just the facts that were there. [Tr. 2714–2715]

The approach taken by Dr. Oxenburgh is often relied on by regulatory agencies (*e.g.,* OSHA and the EPA), academic researchers, and other investigators; it involves having individuals with professional expertise (in Dr. Oxenburgh's case, in ergonomics and productivity measurement) talk to involved individuals, take notes, inspect equipment and facilities, and evaluate what has been observed. For example, in conducting research to obtain data for the economic and technological feasibility analyses to support its standards, OSHA conducts many site visits to gather data on control technologies and work practices, worker exposures, costs of exposure controls, and economic data. In more than 20 years of experience, the Agency has never had reason to conclude that the information collected in this way is not reliable. In fact, site visits and onsite interviews generally provide much more detailed and accurate information than can be obtained in written form alone. OSHA believes that this is why Dr. Oxenburgh ''relied as little as possible on people's * * * written data'' (Tr. 2648): he understands that the answers to specific questions and to follow-up questions are far more revealing than the information in paper records. OSHA finds that the information and data collected by Dr. Oxenburgh and contained in his book are fair and accurate reports on the effectiveness of ergonomic interventions, and the Agency does not agree with Gibson, Dunn & Crutcher's insinuation that the data are unreliable. Further, Gibson, Dunn & Crutcher provide no evidence that the information in Dr. Oxenburgh's book is exaggerated or was misrepresented by safety and health professionals intent on promoting their reputations and careers. OSHA therefore rejects this argument as specious.

Comment: Each case study in Dr. Oxenburgh's book describes ''health, safety and productivity gains'' in broad generalities and rarely provides any quantitative statistics (Ex. 32–241–4, p. 215)

OSHA's Response: OSHA relied only on the 24 case studies from Dr. Oxenburgh's book that did in fact report quantitative changes in the number or rate of MSDs; these quantitative data are reflected in Appendix VI–B in both the preliminary and final risk assessments.

Comment: ''Oxenburgh holds a doctorate in biochemistry but, after 15 years in this field, saw a career opportunity during the early stages of the infamous Australian repetitive strain injury epidemic of the early 1980's and switched disciplines with no further academic training.'' (Ex. 32–241–4, p. 214) ''Primarily * * * Oxenburgh described his expertise as being based on various consulting activities he undertook after becoming ''interested in ergonomics'' and ''join[ing] the Ergonomics Society of Australia [citing Tr. 2700].'' (Ex. 500–197, p. II–12)

OSHA's Response: Gibson, Dunn, & Crutcher impugn Dr. Oxenburgh's professional experience and training but fail to acknowledge that Dr. Oxenburgh has in fact worked in the field of occupational health and safety since 1976 (Tr. 2700) and has practiced in the field of ergonomics for 20 years, since he joined the Ergonomics Society of Australia and became a committee member of the New South Wales division (Ex. 37–24, Tr. 2700). Dr. Oxenburgh also served for several years as a founder and co-ordinator of the Economics and Ergonomics specialist group of the International Ergonomics Association. Over the past 12 years, Dr. Oxenburgh has been an expert witness in more than 700 common law injury claims, in which capacity he has appeared about half the time on behalf of the employer and half the time in support of the plaintiff. Dr. Oxenburgh has also been the principal author on a number of research studies, including several seminal works on the quantifiable effects of early reporting and medical management (see, for example, Exs. 38–188, 26–1405, Winkle and Oxenburgh (1990) cited in Ex. 37–24, Oxenburgh (1997) cited in Ex. 37–24, Oxenburgh (1994) cited in Ex. 37–24). OSHA made Dr. Oxenburgh available to testify at the informal public hearing because of the importance of his work on ergonomics and productivity, and finds Gibson, Dunn, & Crutcher's characterization of Dr. Oxenburgh's qualifications both inaccurate and unjustified.

Comment: Regarding the robot case study contained in Dr. Oxenburgh's book, Dr. Oxenburgh admitted that this is a very unusual case (Tr. 2655) and that the workers are no longer performing that job at all (Tr. 2653). Consequently, there is no ''compelling justification for including it in a case study compilation to broadly represent ways in which employers purportedly can achieve '100%' effectiveness through ergonomic interventions.'' (Exs. 500–197, p. II–13, 32–241–4, p. 226).

OSHA's Response: Although the ''robot'' case study is an unusual case (because employers generally mechanize jobs but only rarely automate them), it is an example of an engineering approach that eliminated a job that had previously caused musculoskeletal injuries among an extraordinary high percentage of workers (60 to 80 percent of the workforce that performed these functions) (Tr. 2654). The engineering control (*i.e.,* the robot) was implemented after facility personnel determined that other options (*e.g.,* job rotation, increased rest breaks, and complete workstation redesign) would not prevent the injuries (Tr. 2654–2655, Ex. 26–1041, pp. 156–158). In his testimony, Mr. Caple also discussed situations in which robots are used in chocolate making and in the automotive industry (Tr. 2624–2625). However, both Dr. Oxenburgh's and Mr. Caple's testimony confirm that robotics are used rarely to control MSD risks. However, because of the unusual nature of the control approach in this case study (*i.e.,* robotics), OSHA has deleted it from the case study data set and is not relying on it in its effectiveness analysis.

Comment: ''It is surely no coincidence that 9 of the 24 Oxenburgh case studies invoked by OSHA cite General Motors as the source of information. At the time * * * General Motors was facing a major 5(a)(1) ergonomics citation, backed up by considerable pressure from its union on the subject of ergonomics * * * [GM] had every incentive to look for outlets to publicize that it was committed to ergonomics and was achieving results.'' (Ex. 32–241–4, p. 231)

OSHA's Response: Gibson, Dunn & Crutcher imply that the information and data taken from these 9 case studies are unreliable because GM was willing to fabricate or distort information to promote its ergonomics activities. OSHA does not believe that General Motors operates in this way, and the Agency notes that Gibson, Dunn & Crutcher provide no evidence of any kind to support their allegations that these 9 case studies are anything other than factual accounts of ergonomic interventions. Accordingly, OSHA is not persuaded by this comment.

Harley-Davidson Case Study (McGlothlin and Baron, Ex. 26–1080)

Comment: The case study documents a general upward trend in MSDs during the study period. ''The only way a decrease in injury rates could be claimed was to pick an aberrational year two to four years prior to program implementation and draw comparisons from that single statistical quirk'' (Exs. 500–197, p. II–14, 32–241–4, p. 227).

OSHA's Response: NIOSH initiated this Health Hazard Evaluation in 1990 and followed up in 1993; the purpose of the evaluation was to identify jobs associated with upper-extremity and back MSDs in the flywheel milling department, and to make recommendations to reduce MSDs in that department. The MSD incidence rates per 100 workers for the study period, as presented in Table 8 of the report (Ex. 26–1080), were 27.6 (1989), 11.5 (1990), 18.7 (1991), 13.4 (1992), and 12.5 (1993) (Ex. 26–1080). These data do not appear to support Gibson, Dunn & Crutcher's claim of a ''general upward trend in MSDs during the study period.'' Gibson, Dunn & Crutcher described the incidence rate of 27.6 for 1989 as a ''statistical quirk'' because it is substantially higher than the incidence rates for 1987 (11.8), 1988 (8.9), and 1990 (11.5) (Ex. 32–241–4, p. 227). The case study indicates, however, that this increased rate was associated with hiring a nurse between 1988 and 1989 who ''brought new vigilance to the reporting of musculoskeletal disorders'' (Ex. 26–1080, p. 12), suggesting that the lower rates reported for 1987 and 1988 reflect the underreporting, rather than low incidence, of MSDs. Further, the case study suggested that the MSD incidence for 1990, which was substantially lower than that for 1989 or 1991, may have decreased because of a sudden 20-percent increase in the department's workforce: new workers may have under-reported musculoskeletal problems, or it is possible that the disorders did not become symptomatic until the following year (Ex, 26–1080, pp. 12–13). For these reasons, OSHA does not agree that the MSD rate for 1989, which is taken as the base year for comparison with post-intervention years, is necessarily a statistical aberration, but rather that the lower MSD rates for the surrounding years may reflect underreporting of MSDs and abrupt increases in the workforce of the establishment. However, because of the concern raised about the representativeness of the injury rate for 1989, OSHA is basing its estimate of program effectiveness from this study on the injury rate for 1991, which represents the first year in which interventions were planned and implemented.

Telecommunications (Video Display Terminal (VDT) operator) Case Study (Tadano, Ex. 26–1337)

Comment: ''OSHA attributed significance to a '40.8' percent reduction in 'Total MSDs' allegedly achieved by an ergonomics program * * * [T]his reduction took place after a very substantial increase in MSD reports during the preceding period. The article suggests that this claimed reduction may have arisen from 'a certain operator hysteria about * * * catching [repetitive motion sickness], * * * possibly connected to sentiments, fueled by union activities, that 'management was * * * not doing enough * * * to curb this epidemic'' ' (citing Ex. 30–1337, p. 69). The reported reduction, therefore, might have nothing to do with the effectiveness of the ergonomics program and more to do with the statistical effect of ''regression to the mean'' (Ex. 500–197, pp. II–17–18).

OSHA's Response: This case study describes an ergonomic intervention implemented by a telecommunications establishment to address an increase in the rate of upper-extremity MSDs among VDT operators. There is nothing in the case study that supports Gibson, Dunn & Crutcher's contention that the observed decline in the number of upper extremity MSD cases and their associated medical costs was due to ''regression to the mean'' following an unusual increase in MSD rates, nor is there any suggestion by the author that ''operator hysteria'' was solely or even primarily responsible for the increase in the MSD rate prior to instituting the intervention. When reports of MSDs began to increase, the article stated that the ''* * * medical department staff was especially concerned, as they were aware that a similar department of a company branch in an adjacent state had been faced with [repetitive motion syndrome] in 'epidemic proportions'.'' (Ex. 26–1337, p. 69) The article also stated that ''* * * the job was considered stressful and monotonous by many operators,'' and that ''* * * [the] labor management relationship had previously been good.'' (Ex. 32–1337, p. 69) The author clearly attributed the decline in MSD cases following the ergonomic intervention to the intervention itself, and reported that ''* * * these results indicate the value of a positive approach to prevention of this occupational group [of disorders].'' (Ex. 26–1337, p. 70) Therefore, OSHA finds that it is appropriate to rely on this case study as part of its data set of ergonomic interventions.

Comment: ''Tadano also explains at length that CTDs 'have a multifactorial etiology' and that it is often not possible to attribute trends to any single intervention. She concludes:

> In the current study, so many factors were changed * * * that success or improvement cannot be attributed to any single factor. Also the data were limited, in that the sample size was small and the duration of time measured was limited.'' [Citing Ex. 26–1377, p. 70]

Yet, OSHA does exactly what Tadano warns it no[t] to do ''it attributes the entire * * * success or improvement * * * described in the article to the * * * single factor * * * of ergonomic interventions in the workplace'' (Ex. 32–241–4, p. 218–219).

OSHA's Response: Gibson, Dunn & Crutcher omitted an important part of the excerpt they quote from the Tadano study. The excerpt should read that ''* * * so many factors were changed (*i.e.,* worker methods, work-station design, addition of exercises, and mini-breaks) that success or improvement cannot be attributed to any single factor.'' The factors mentioned by Tadano all relate to the ergonomic interventions described in the study, and all would be considered appropriate engineering, administrative, and medical management interventions under the final rule. Thus, OSHA did not attribute the reduction in the MSD rate inappropriately, Gibson, Dunn & Crutcher imply; instead, OSHA, as well as the author of the study, attribute the post-intervention reduction in MSD rate to the collective effect of all of the components of the ergonomic intervention.

Leiyu Shi Study (Ex. 26–1099)

Comment: Although this study is a randomized study, there are serious flaws including small size and lack of sufficient study period to eliminate Hawthorne effect or other variables as potential explanations (Tr. 6823; Ex. 32–241–3–7, p.15). The author admits that ''* * * his analysis 'contains a number of limitations,' including the need for further examination and empirical testing to establish 'the reliability and validity' of the methodology he used and the very real possibility of 'a Hawthorne effect among the participating units' because employees knowing they are being studied react unusually and their reported behavior change may be more a result of their enthusiasm rather than that of an injury prevention program.'' [citing Ex. 26–1099, p. 210] (Ex. 32–241–4, p. 219).

OSHA's Response: The Leigu Shi study is a randomized trial of a back injury prevention program implemented among county employees; the program consisted of a combination of education, training, physical fitness activities, and ergonomic improvements. The author acknowledged that it was not possible rule out a Hawthorne effect bias in the results. However, although the author was aware of the potential for some confounding, he made several observations about the effectiveness of the back injury intervention program studied:

> The results of the study lend support to the widely held belief that health promotion in the workplace can significantly reduce employee health risks. * * * [T]he study offers suggestive evidence for the initial benefits of a back injury prevention program. Whether such interventions will continue to reap benefits in future years depends, to a large extent, on a *favorable work environment* and the maintenance and continuation of positive behavioral changes (emphasis added) (Ex. 26–1099, pp. 209–210).

I response to general comments in the record that the case studies OSHA used to indicate program effectiveness are seriously biased, OSHA does not dispute that these case studies, like all such reports and investigations, may reflect some bias; no study can eliminate all biases or potential confounders. However, the large number of case studies accumulated by the Agency makes it highly unlikely that any single unaccounted for confounder, such as the Hawthorne effect, could explain the consistent results reported in these studies as well as the effect OSHA postulates: that ergonomic interventions work.

Malcolm Pope Case Study of Telecommunications Workers (Ex. 26–1073)

Comment: As an example of an ''emphatic disclaimer'' OSHA's critics claim the authors of the technical articles made and OSHA ignored Pope explains in his article [which was used by OSHA in its effectiveness analysis] that ''there are other factors involved * * * [in low back pain] such as abnormal anatomy, the physical fitness of the individual, changes related to age and previous injury.'' (Ex. 32–241–4, p. 219, citing Ex. 26–1073, p. 450).

OSHA's Response: The Pope paper discusses the etiology of work-related low back pain and approaches for reducing back injury rates. Part of this report presents a case study of an ergonomic intervention in a telecommunications manufacturing facility. In discussing the etiology of low back pain, Pope stated, almost as an aside, that other factors may be involved; however, in discussing the etiology of low back pain, Pope emphasizes the importance of repeated biomechanical load on tissues. For example, the article stated that ''all connective and structural tissues [*i.e.,* even in those individuals who do not have abnormal anatomy, poor physical fitness, or advanced age] will fail if subjected to loads that are too high for too long a period of time without an opportunity for repair to occur'' (Ex. 26–1073, p. 450). In addition, he notes that ''[l]ow back pain has, in most cases [of over-exertion injuries reported], occurred due to a mechanical overload to one of the tissues of the back'' (*i.e.,* lifting to much, too far, too long, etc.) (Ex. 26–1073, p. 450). Dr. Pope concluded the section of his paper on etiology by stating that ''The key issue for those involved in the prevention of occupational injuries is to use epidemiologic information so that the relationships between load, repetition rate and exposure can be identified.'' (Ex. 26–1073, p. 450)

Dr. Pope then described the case study that exemplifies his approach (Ex. 26–1073, p. 453, abstract). The results of the case study showed that, within one year of implementing an ergonomics program that included engineering changes, the incidence rate of significant repetitive trauma disorders decreased from 1.1 cases per 100,000 working hours to 0.26 cases/100,000 working hours and lost work days decreased from 1,000 to 129 (*i.e.,* an almost eightfold decrease in lost work days). Dr. Pope concluded his paper as follows:

> An ergonomic approach, soundly based on biomechanical principles, will be effective in reducing such injuries if the correct management approach is taken. [Ex. 26–1073, p. 454]

Based on Dr. Pope's discussion of the etiology of low back pain and the conclusions that accompany the case study, OSHA does not agree that the reference to ''other factors'' cited by Gibson, Dunn & Crutcher represent an ''emphatic disclaimer'' of the case study's findings.

Westgaard and Aaras Study of a Telecommunications Manufacturer (Ex. 26–1026)

Comment: The authors note in this paper that ''musculo-skeletal illness may also develop as a result of other factors than work load, for instance as a complication because of other illnesses, due to general defects of the musculo-skeletal system, due to muscle spasms as a consequence of problems of a psychological nature, or to strenuous leisure time activities [;t]hus, one should not conclude that the work station is the major causal factor for any individual case of musculo-skeletal disorders' (Ex. 32–241–4, p.219, citing Ex. 26–1026, pp. 173–174). This statement represents another ''disclaimer'' that weakens the case study.

OSHA's Response: This study was a formal investigation of sick leave and medical records to evaluate the effectiveness of ergonomic improvements made in 1975 in a telecommunications parts manufacturing plant. Although the authors stated that ''* * * one should not conclude that the work station is the *major* causal factor for any *individual* case of [MSD]'' (emphasis added), there is no question that the investigators believed that reducing exposures to biomechanical load was responsible for reducing the sick leave associated with MSDs:

> There is no doubt that there has been an unusually high rate of musculoskeletal illness among the workers * * * in general. * * * It is also clear that the work situations have been strenuous, with the strain mainly affecting a limited number of muscles in the shoulder and neck region * * *. [I]t is very unlikely that those employed at the [work station] * * * have a sufficiently different life situation to other women of the same age to explain the group differences in sick leave due to musculo-skeletal disorders. The work load and, specifically, the strain on shoulder and neck muscles, *must* therefore be considered a *major* causal factor in the development of musculo-skeletal disorders among [the] workers [Emphasis added]. [Ex.26–1026, p. 174]

Thus, based on the specific conclusions reached by the authors of this study, OSHA finds that it appropriate to include this study among the data base of case studies that describe the effectiveness of ergonomics programs.

Meatpacking Case Study (Ex. 26–1043)

Comment: Group is too small to support statistically valid conclusions. Baseline of four reported injuries at meatpacking operation (Ex. 32–241–4, p. 220, see footnote 805).

OSHA's Response: This article describes the comprehensive ergonomics program implemented by a major meatpacking company. Although the program was implemented for ''all plant locations'' of the company, the article reports quantitative results only for the bacon department. Although the number of MSD cases is small, Gibson, Dunn & Crutcher fail to mention that the reduction experienced by the department was a decrease from four CTDs in *one month* to none in the *six months* following the implementation of the program (Ex. 26–1043, pp.138 & 140), a change that the author clearly attributed to the use of employee rotation in the department.

Ice Cream Manufacturer Case Study (Ex. 26–1100)

Comment: The group is too small to support statistically valid conclusions. Baseline of four compensation claims, not necessarily attributable to MSDs (Ex. 32–241–4, p. 220, see footnote 805).

OSHA's Response: This case study of a mid-sized ice cream manufacturer (230 workers in summer, 60 in winter) clearly identifies the four workers' compensation cases as involving ''soft tissue'' (Ex. 26–1100, p. 52). All of these claims occurred after the installation of six new workstations, whereas in the preceding seven years (before the workstations were installed) there had been no such claims. In addition to the decrease in the number of claims after the intervention, the implementation of ergonomic changes resulted in a decrease in absenteeism from ten to four percent, an increase in productivity of as much as 55 percent, and an overall increase in morale (Ex. 26–1100). Thus OSHA finds it appropriate to include this study in its database.

Cattle Feed Processing Case Study (Ex. 26–1046)

Comment: Group is too small to support statistically valid conclusions. Purportedly scientific article making claims based solely on the experience of two cattle feed processing employees without any attempt to explore the etiology of the reports (ex. 32–241–4, p. 220, see footnote 805).

OSHA's Response: This study describes a case in which a processing plant began producing experimental cattle feed in a manual operation. According to the article, the operation ''was apparently initiated without either pre-run trials or consideration of occupational health and safety issues'' (Ex. 26–1046, p. 27). The injuries sustained by the two employees were shown to have been a direct result of these specific workplace activities; between two and four weeks after beginning these specific workplace activities, both of the workers sustained irreversible back injuries. After engineering controls were implemented, there were no incidents of reported back pain during three subsequent trials of the redesigned process. The author reported that ''* * * [h]ad such countermeasures been implemented immediately, the irreversible injury would have been prevented'' (Ex. 26–1046, p. 28). Again, OHSA finds this study is appropriately included.

Hand Tool Operations Case Study (Ex. 26–1070)

Comment: Group is too small to support statistically valid conclusions: ''the data are inadequate for rigorous statistical evaluation'' (Ex. 32–241–4, p. 220, see footnote 805, citing Ex. 26–1070, p. 678).

OSHA's Response: This was a formal study of OSHA log and medical records at a telecommunications manufacturing facility during the implementation of a program to introduce redesigned hand tools and provide employee training on ergonomics; one of OSHA's expert witnesses, Dr. Thomas Armstrong, was a co-author of this study. The plant-wide incidence rate of OSHA reportable repetitive trauma disorders prior to the implementation of engineering and administrative ergonomic controls was 2.2 cases per 200,000 workhours and 1,000 lost workdays. In addition, incidence rates were as high as 4.6 percent in some areas of the facility and work restrictions were impeding the balance of production lines. Four departments accounted for 68 percent of all repetitive trauma injuries, and 48 percent of all repetitive trauma injuries occurred among assemblers (Ex. 26–1070, pp. 674, 676–677).

After the implementation of controls, repetitive trauma disorders decreased to 0.53 per 200,000 workhours and only 129 lost workdays. The authors stated that the contribution of the control program to the reduction in MSDs seen in the facility ''cannot be statistically tested using the available medical data,'' but emphasized that they believe the control program was ''an important factor in this reduction'' (Ex. 26–1070, p. 677) and stated that the program ''appears very promising'' (Ex. 26–1070, p. 678). Based on the authors own conclusions, OSHA finds that the reported reduction in MSDs in this plant are apprpriately attributed to the ergonomic interventions described.

Material Handling at Grocery (OSHA Site Visit) (Ex. 26–1176)

Comment: Group is too small to support statistically valid conclusions. ''From these data, it is not certain that costs associated with CTDs, the severity of CTDs (as represented by cost per claim), or the impact of CTDs on total medical claims have changed significantly for the long term'' (Ex. 32–241–4, p. 220, see footnote 805, citing Ex. 26–1176).

OSHA's Response: This case study resulted from an OSHA-sponsored site visit to a retail grocery establishment. Although the site visit report acknowledges its limitations in predicting long-term effects from the employer's newly implemented ergonomics program, it also stated the following:

> [I]t appears that [worker CTD compensation] claims have declined somewhat, but the program has not really been in place long enough to be able to verify a trend * * * It does look promising, however, particularly in terms of the number of CTD claims, which have fallen even while total employment has risen, and perhaps the average cost per claim.
>
> On a division-wide basis, members of the company CTD committee think that, as a result of the CTD strategy implementation, the numbers of CTD-related injuries and illnesses have decreased, the associated costs of claims (workers' compensation and medical) have decreased, employee complaints have been reduced, and employee morale has improved (Ex. 26–1176, pp. 12–13).

Thus, it is clear that this employer representative attributed the observed decline in MSDs directly to implementation of the program, and OSHA therefore finds it appropriate to include it in the data set being relied on by the Agency to evaluate the effectiveness of ergonomic interventions.

Garg and Owen Study of Ergonomic Interventions in a Nursing Home (Ex. 26–1093)

Comment: Group is too small to support statistically valid conclusions. ''[L]arge-scale studies in different nursing homes are necessary to confirm the * * * findings'' in the article (Ex. 32–241–4, p. 220, see footnote 805, citing Ex. 26–1093).

OSHA's Response: The study was conducted in two units of a nursing home which employed 57 nursing assistants. As a result of the controls implemented, the incidence rate for back injury decreased from 83 per 2,000,000 work-hours to 47 per 2,000,000 work-hours. The authors concluded that ''an appropriate ergonomic intervention program offers great promise in reducing physical stress and risk of low-back pain to nursing personnel.'' OSHA agrees that, as the authors stated in their article, the specific findings of this one study may not reflect the results achieved in other establishments that implement similar ergonomic measures. Garg and Owen explain that implementing such measures requires consideration of staffing levels, training, workload, and administrative support (Ex. 26–1093). However, the study by Garg and Owen is only one of several case studies used by OSHA to examine the effectiveness of ergonomics programs in nursing homes and other health care industry sectors (see Appendix VI–2 in this section of the preamble). These other studies also report reduced MSD rates that are attributed to ergonomic interventions, many of them similar to those investigated by Garg and Owen (*i.e.,* use of mechanical devices for patient lifting, modifying showers and toilets for easier access). Therefore, OSHA does not agree that it is inappropriate to include the Garg and Owen case study in the database, despite the authors' caution.

Couch, Summary of Six Case Studies (Ex. 26–1086)

Comment: The importance of non-work factors such as gender and age are mentioned as potential contributors. ''The above examples of the cost benefits of ergonomics are quite positive and indicate that ergonomics does seem to reap monetary rewards as well as improve worker well being. However, there are many factors that have not been accounted for or controlled in these reports; these factors, such as changes in the economy that reduce job turnover or changes in production technology and product lines that may eliminate high risk jobs or leave only the survivors in remaining jobs, may also contribute to the apparent payback. Because ergonomic case studies such as these are done 'in the field,' it is very difficult to hold these independent or external variables constant'' (Ex. 32–241–4, p. 220, see footnote 805, citing Ex. 26–1086).

OSHA's Response: OSHA recognizes that the case studies contained in Appendix VI–2 are, because of their real-world rather than laboratory nature, unable to control for a number of factors that could affect injury and illness outcomes; some of these factors are mentioned in the Couch article (Ex. 26–1086) and in Gibson, Dunn & Crutcher's comment. However, OSHA is not basing its finding that ergonomic interventions are effective on any single study or a few case studies. Instead, OSHA has identified more than 200 case studies from the record, all of which document reductions in MSD numbers or rates following implementation of ergonomic interventions. These case studies reflect a wide variety of industry sectors, workplace conditions, labor market conditions, and technologies. Nevertheless, despite the presence of confounding or modifying factors such as those mentioned in the Couch article, all of these studies attributed the observed reductions in MSD rates primarily to the ergonomic interventions described. Because such a large number of case studies yields such consistent results, OSHA finds it unlikely that the kinds of factors identified by Couch, rather than ergonomic interventions, were primarily responsible for the reductions in MSD rates reported in this large group of studies.

Automobile Cable Manufacturer (OSHA Site Visit) (Ex. 26–1181)

Comment: OSHA's estimate of the reduction in the number of MSDs pre- and post-intervention are based on numbers of illness cases, lost workday cases, and lost work days in 1991 and 1993. However, the statistics for 1993 represent only the first 9 months of the year. Further, the establishment reported an increase in the total number of injuries, which must include some MSDs, from 46 in 1991 to 65 in the first 9 months of 1993. OSHA cannot base its effectiveness estimate solely on the reduction in illness cases reported (Ex. 32–241–4, p. 222).

OSHA's Response: The site visit report clearly states in a footnote to the ''1993'' column which of the data ''covers [the] period from January to September 1993'' (Ex. 26–1181, p. 10). If the statistics for 1993 are extrapolated to cover a full year, based on the experience of the first 9 months, declines in lost workday cases and illnesses are still apparent: lost workday cases decline from 48 (1991) to 36 (1993) (a 25-percent reduction); the number of lost workdays decline from 1,287 (1991) to 367 (1993); and the number of illnesses decline from 47 (1991) to 23 (1993) (a 51-percent reduction). Although the report clearly indicates that the number of total injuries increased from 1991 to 1993, the report also states that ''[t]he facility believes that their ergonomics program has contributed to decreases in the following: number of overall illnesses, number and costs of worker's compensation claims, number of work days and lost workday cases, medical (*i.e.,* non-compensated disability) cost, and turnover'' (Ex. 26–1181, p. 9). These claims are supported by the data presented in the report. No reason was given for the increase in the total number of injuries from 1991 to 1993, nor was there any evidence in the report to suggest that the rise in total number of injuries was attributed to an increase in the number of MSDs. It is apparent, however, from the report that the employer would have been likely to classify some MSDs as injuries rather than illnesses. Therefore, OSHA has revised its analysis for the final rule to reflect that lost workday cases declined by 25 percent, and is not relying on the illness statistics presented in the report for its effectiveness analysis.

Luopajarvi et al.Study of a Food Packing Establishment (Exs. 26–1042, 26–1090)

Comment: OSHA attributed to an ergonomics program the elimination of hand MSDs from a pre-intervention level of 51 MSDs in 1976. ''The claim is false: the exhibit makes no reference to elimination of hand MSDs, and the underlying data tables confirm the existence of continuing injury reports. Moreover, ergonomic interventions were not even proposed at the plant until 1977, a year in which MSDs dropped to a level (20) more consistent with the lower rates existent prior to this year.'' (Ex. 32–241–4, p. 220).

OSHA's Response: Tables 3 and 4 of Ex. 26–1090 (p. 430) provide data on the numbers of hand MSDs from 1972 to 1984 in this food packaging facility. The incidence of hand MSDs increased steadily from 1972 to a high of 51 cases in 1976 and 20 in 1977; between 1979 and 1984, the table reported between 0 to 1 MSDs occurring annually, indicating that the problem had been virtually eliminated. OSHA has revised the entry for this case study in Appendix VI–2 to report the study's findings more precisely. With reference to the second part of Gibson, Dunn & Crutcher's comment, OSHA did not rely on the hand MSD statistics for its overall measure of program effectiveness, but on data presented in Table 5 of the article, which reported the number of MSDs of the neck and upper extremity in 1977 and 1981 and reflect an overall reduction in the number of MSD of 47 percent. Thus, OSHA is using 1977 as the baseline year, the year in which ergonomics interventions were being proposed.

Footwear Assembly Case Study (Ex. 26–1059)

Comment: OSHA attributes a 62-percent decline in MSDs over a 2-year period to an ergonomics training program. However, the article explains that ergonomic remedies were unsuccessful and the ergonomics training program ''* * * was actually a 'behavioral management' program designed to improve worker attitudes and morale'' (Ex. 32–241–4, p. 225). This case study is consistent with evidence that ''reports of pain are rooted in psychosocial factors rather than workplace 'hazards,' [and that] the attitude adjustment strategy apparently achieved what ergonomics could not.'' [Ex. 32–224–4, pp. 225–226]

OSHA's Response: This article describes a training program implemented at a footwear manufacturing facility that had 700 workers, 84 percent of whom were involved in repetitive tasks. The company experienced a rise in serious and lost-time upper-extremity MSDs throughout the early 1980's. The article does not claim, as the comment contends, that ''ergonomic remedies were unsuccessful.'' Instead, the article stated that several attempts were made to develop a ''safety program'' that was not further described (Ex. 26–1059, p. 52). If engineering solutions to address MSDs were implemented, they were not discussed in the article; instead, the article reported that ''because of the expense of workstation redesign in this very old facility, almost all human-factors engineering measures were also deemed to be impractical'' (Ex. 26–1059, p. 52). Therefore, no claim can be made as to the success of an ergonomic intervention based on engineering at this facility. The comment states that the program implemented was actually '' 'a behavioral management program' designed to improve worker attitudes and morale.'' Behavior management is defined in the article as ''simply the management of people in the work place in such a way that they interact with the environment in the most safe and efficient manner'' (Ex. 26–1059, pp. 51–52). The training ''attempted to educate employees on the causes and effects of [cumulative trauma disorders] * * * and the state workers' compensation system.'' (Ex. 26–1059, p. 53) The final rule requires employers to provide similar information to all employees on the causes and characteristics of MSDs. The program at the facility also encouraged employee participation, another important component of the final rule. OSHA does not agree with the comment that the case study demonstrates that psychosocial factors are more important that biomechanical factors; OSHA's review of the scientific evidence on the role of psychosocial factors is presented in the Health Effects section (Section V of the preamble), where the Agency finds that, although psychosocial factors play a role in the etiology of work-related MSDs, they do not outweigh the significance of exposure to biomechanical factors in the workplace and are independent of biomechanical efferts.

Sewing and Cutting Operations Case Study (Ex. 26–1060)

Comment: This is an article written by an OSHA area office employee about an inspection of a sewing facility. ''The article actually reports, however, that there was a steady decline in reported CTD rates beginning long before any ergonomic interventions: 26% in 1987, 18% in 1988, and 15% in 1989'' [citing Ex. 26–1060, p. 1]. The article does not identify exactly when ergonomic controls were implemented, but it does state that rates continued to decline to 14.6% in 1990 and 6.8% in 1991, but increased to 11% in 1992. The article also noted that ''there was an increase initially reported'' after ergonomics controls were implemented, which could only refer to the jump from 6.8% to 11%. Since no statistics are given for years after 1992, these data would suggest, if anything, that ergonomic controls *reversed* a previous trend of declining injury reports at this plant, prompting a 62% *increase* from 6.8% to 11%.'' (emphasis in original) [Ex. 32–241–4, p. 223]

OSHA's Response: This article reports on an OSHA inspection conducted at a sewing facility in October of 1989. Since the inspection, at least through 1992, the company had been working under an abatement plan that required the facility to develop and implement a comprehensive ergonomics program ''from the ground up'' (Ex. 26–1060, p. 3). In 1992, the year in which the MSD rate increased over that of 1991, the report stated that there were ''fewer incidents reported [overall],'' which suggests that employment in the plant had fallen since 1991 (there had previously been about 100 workers at this plant). There were also no surgeries reported in 1992, compared to 13 reported between 1987 and 1989 (Ex. 26–1060, p. 2). The report concludes that the ''lost workday injury rate has been effectively reduced,'' and noted that the number of employee complaints of MSD symptoms had fallen from 34 in 1991 to 14 in 1992 (Ex. 26–1060, p. 6). Therefore, OSHA does not agree with the analysis of this report by Gibson, Dunn & Crutcher, which suggests that the ergonomics program led to an increase in the rate of MSDs.

Poultry Processing Case Study (Ex. 26–1174)

Comment: ''OSHA claims that 'ergonomic solutions' at a poultry plant decreased recordable injuries and illnesses * * * from 10–14/100 workers (1988–89) to 7/100 workers (1991). * * * [T]he only two notable dips in recordable injury rate—which includes *all* injuries and not just MSDs—occurred between 1987 and 1988, when the rate declined from 14.0 to 10.5, and between 1989 and 1990, when there was a further drop from 10.5 to 7.5. The first occurrence took place before ergonomics began, and the second occurrence took place before the majority of the program was rolled out.'' (Ex. 32–241–4, p. 224) OSHA's attribution of the reduction in MSDs to the ergonomics program, when the reduction occurred prior to program implementation, and its use of total injury rates as if they were MSDs are ''blatant distortions of the truth.'' (Ex. 32–241–4, p. 224)

OSHA's Response: This case study is a site visit report of a poultry slaughtering and processing plant. The injury rate history of this plant was as follows: 14.0 in 1987, 10.5 in 1988, 10.5 in 1989, 7.5 in 1990, and 7.0 in 1991 (Ex. 26–1174, p. 17). The comment by Gibson, Dunn & Crutcher suggests that the reduction in injury rate that occurred in 1990 occurred prior to implemetation of most of the ergonomics program. However, the site visit report states clearly that $410,000 in capital cost was incurred for engineering controls in 1990, compared to $242,500 in 1991, indicating that most engineering improvements to address MSDs were made in 1990 (Ex. 26–1174, pp. 9–10). Therefore, OSHA does not agree that the 1990 injury rate reflects a time when most of the program had not yet been implemented. Further, the first drop in injury rate, which occurred in 1988, can be at least partly attributed to the large increase in employment in 1988 (from 950 workers in 1987 to 1,350 workers in 1988) (Ex. 26–1174, p. 17). Because of the change in employment in 1988, OSHA used the injury rates from both 1987 and 1988 as baseline years to calculate the percent reduction in injury rate pre- and post-implementation (*i.e.,* OSHA used an average baseline rate of 12 injuries per year). Additional evidence that the drop in injury rate in 1990–1991 can be attributed to the ergonomics program comes from other statistics provided by the facility that show drops in both worker absenteeism and turnover in 1990–1991 compared with earlier years; in contrast, there was no drop in absenteeism or turnover rates to accompany the drop in injury rate seen from 1987 to 1988 (Ex. 26–1174, p 17). Therefore, OSHA finds that the decline in injury rate seen in the 1990–1991 time period is most likely to have been the result of the ergonomic improvements made in 1990 and 1991 at this factility.

Packaging Sugar Cubes Case Study (Ex. 26–1041, Case 41)

Comment: OSHA attributes a 100-percent reduction of MSDs at a sugar cube packing operation, where the author of the study, Dr. Oxenburgh, stated that ''the *risk* of serious strain injuries to the hands and upper limbs has been virtually eliminated'' (citing Ex. 26–1041, p. 230, emphasis added). ''The statement only reflects the subjective judgement of Dr. Oxenburgh about 'risk'; he provides no actual data concerning actual injury experience after the change.'' (Ex. 32–241–4, p. 225) Further, the numbers are too small for statistical analysis, and ''Oxenburgh's unverified hunch about risk has no place in a statistical analysis.'' (Ex. 32–241–4, p. 225)

OSHA's Response: This case study describes a sugar cube packing operation in which 5 employees used a tool to pack cubes tightly into boxes. Because of the hand posture and pressure required to operate the tool, injuries to the hand and upper limbs occurred in about 1 out of 4 operators (*i.e.,* 25 percent of workers). After implementing an engineering and marketing solution that allowed the cubed sugar to be packed loosely into bags, productivity increased to the point where only 2 workers were required for the packing operation. The complete quote partially cited by Gibson, Dunn & Crutcher from the case study reads as follows: ''The risk of serious strain injuries to the hands and upper limbs has virtually been eliminated and has led to considerable savings in sickness absence and workers compensation.'' Although no statistics are presented, this is significant because it demonstrates a clear benefit from the change to the process. Rather than representing an ''unverifiable hunch,'' as Gibson, Dunn & Crutcher suggest, OSHA finds it logical to conclude from Dr. Oxenburgh's statement that no serious injuries occurred among the two remaining operators because the change eliminated the forceful repetitive motion (*i.e.,* pressing the sugar cubes together) responsible for the prior injuries.

Computer Manufacturer Case Study (Ex. 26–1068)

Comment: OSHA attributes a 41-percent reduction in upper-extremity disorders in 1994–1995 and a further 50-percent reduction in 1995–1996 to an ergonomics program. However, the program was implemented in 1991, after a year (1990) in which the company's upper-limb disorder rate was 0.5 per 100 workers. This rate increased to a high of 2.5 cases per 100 workers in 1994, after which they drop in 1995 and 1996. ''Thus, the reported declines in 1995 and 1996 brought the company down to approximately a 0.7 rate—a 40-percent *increase* over the experience it had during the last year before ergonomic interventions were introduced.'' (Ex. 32–241–4, p. 226, emphasis in original)

OSHA's Response: Although this computer manufacturer did implement an ergonomics program in the early 1990s, according to the case study, the program began ''with a reactive approach, addressing individuals.'' This isolated approach could be a reason why an immediate reduction in upper-limb disorders was not realized. In addition, ''[p]art of the increase in the number of CDT cases per year [from 1990 through 1994] can be attributed to the company's rapid growth, which more than doubled during that period.'' The trend was not reversed until the company, beginning in 1993, ''spent at least two days a week performing evaluations, held mandatory ergonomic training classes for high risk groups including technical publications, order[ed] administration and customer technical phone support, and created and distributed a 16-page ergonomics brochure.'' Additionally, with the growth in 1994 and 1995, the company purchased new furniture ''allowing employees a greater range of postures and flexibility.'' It was this expanded and comprehensive approach that led to the 41 percent drop in reportable upper-limb disorders from 1994 to 1995 and the further decrease of 50 percent in reportable CDT cases from 1995 to 1996 (Ex. 1068, pp. 7–8). Therefore, OSHA finds that the decline experienced in MSD rates beginning in 1995 is consistent with the company's implementation of ergonomic improvements that consisted of appropriate education and training of its workers, as well as workstation modifications.

Medical Device Manufacturer Case Study (Ex. 26–1183)

Comment: OSHA apparently attributes a 29-percent reduction in MSD rates from 1990 (2.1 cases per 100 workers) to 1992 (1.5 cases per 100 workers) to an ergonomics program (Ex. 32–241–4, p.228, footnote 857). However, ''the corporation did not begin to address ergonomic issues until 1991, did not formalize the program until 1993, and did not conduct training or implement the vast majority of its workplace modifications until 1992 or 1993. The result was a very substantial increase in 'ergonomics incidence rate' to 2.8 [per 100 workers] in the first three months of 1993 from * * * pre-intervention levels.'' (Ex. 32–241–4, p. 228)

OSHA's Response: This case study is a site visit report to a manufacturer that produced suction canisters used to collect blood during surgical procedures. The company began to address ergonomic issues in 1989 (a year in which their MSD rate was 5.2 cases per 100 workers), and first began to implement controls in 1991 (Ex. 26–1183, p. 2). OSHA used 1990, the first year prior to implementation of ergonomic controls, as the base year in its effectiveness analysis. The company continued to implement controls in 1992 and 1993. Since injury statistics were only available for the first 3 months of 1993, OSHA believed that a reliable injury rate could not be determined for that year. OSHA does not agree that the statistics available for the first quarter of 1993 show that the MSD rate was increasing because it reflected too short a period. Consequently, there are no data available in the report to permit an assessment of the effect of ergonomic interventions implemented in 1992 or 1993 at this facility. OSHA attributed the decline in MSD rates from 1990 to 1992 to the improvements made in 1991, based on the report's finding that ''[t]he facility believes that their ergonomics program has contributed to a general decrease in the plant's annual incidence rate for ergonomic-related injuries and illnesses.'' OSHA believes that this is an appropriate interpretation of this study. (Ex. 26–1183, p. 10)

Vehicle Seat Assembly Case Study (Ex. 26–1076)

Comment: This case study reported that the number of tendinitis and carpal tunnel syndrome cases had dropped 93 and 96 percent, respectively, but OSHA ignored information that the broader category of ''strains and sprains'' increased over the same period.

OSHA's Response: This is a case study of an automobile seat manufacturer that began experiencing problems with MSDs shortly after beginning full production. The ''slight'' increase in sprains and strains reported by the case study occurred during a time when the numbers of tendinitis and carpal tunnel syndrome cases dropped dramatically. According to the manufacturing manager, the increase in strains and sprains ''reflected the employees reporting the discomfort and pain [of MSDs] earlier.'' (Ex. 26–1076, p. 66) Because the increase in strain and sprain reports was described as ''slight'' by the manufacturing manager (Ex. 26–1076, p. 66), OSHA finds that the much larger decreases in the numbers of tendinitis and CTS cases fairly reflect the results achieved by the company's ergonomics program.

Aircraft Parts Manufacturer Case Study (Ex. 26–1179)

Comment: OSHA attributes a reduction of 96.2 percent in total MSD cases at an aircraft parts manufacturer ''based solely on data referring to specific diagnosis of CTS, ignoring information * * * clearly stating that the total 'number of reportable ergonomic injuries and illnesses [not just CTS] has actually increased since the ergonomics program began.' '' (Ex. 32–241–4, p. 232, citing Ex. 26–1179, p. 15, emphasis in original)

OSHA's Response: This case study is a report of a site visit conducted at an aircraft parts manufacturing facility. A formal ergonomics program was initiated in 1988, but did not have ''solid commitment from upper management and * * * [was] not readily accepted by the workforce.'' (Ex. 26–1179, p. 1) In 1991, the facility implemented a redesigned program following an OSHA citation, ''which [the program] proved to be very successful since it had the support of upper management and relied on hourly employees working together to identify and implement solutions to ergonomic problems.'' (Ex. 26–1179, p. 1) The facility reported that the *percentage of total recordable* injuries represented by ergonomics cases rose from 13.5 percent in 1991 to 20 percent in 1992 (*i.e.*, MSDs represented a larger proportion of all injuries and illnesses in 1992 than in 1991). This does not necessarily mean that the number or rate of MSDs increased during this period, as Gibson, Dunn & Crutcher claim. In fact, facility representatives stated that ''the actual number of [MSD] cases is at least holding steady.'' (Ex. 26–1179, p. 15) However, because the site visit report makes clear that there were MSD cases that occurred in the facility in addition to the CTS cases used by OSHA to calculate program effectivness, and because the report provides no statistics or other details on the number or rate of these cases, OSHA is no longer relying on this case study in its effectiveness analysis for the final rule.

Office Furniture Manufacturing Case Study (Ex. 26–1102)

Comment: OSHA claimed a 67-percent reduction in MSD rate, apparently from a ''passing reference to a claimed reduction in ''incidence rate'* * * (''incidence of what is not specificed)'' (Ex. 32–241–4, p. 232). However, the information presented in OSHA's Appendix VI–2 shows a reduction only from 21 per 100 workers in 1989 to 19 per 100 workers in 1991–1992, a change of only 9 percent ''that is of dubious statistical significance'' (Ex. 32–241–4, p. 232).

OSHA's Response: In OSHA's final analysis of the effectiveness of ergonomics programs, OSHA is basing its measure of effectiveness for this case study on the reported 9-percent decline in MSD rate. Regarding the comment on statistical significance, it was not OSHA's intent to limit its analysis of case studies only to those studies where the reported change in MSD rate could be shown to be statistically significant, primarily because most of the case studies lacked information to perform tests of statistical significance. OSHA believes it important to base its analysis on all of the experiences reported in the set of case studies, however large or small the result attributed to ergonomics interventions, and not to limit its analysis to the small group of case studies for which tests of significance could be performed.

Freight Truck Terminal Operations Case Study (Ex. 26–1177)

Comment: OSHA assumes a 46-percent decline based on a table that shows 13 MSDs occurred in 1989 and 7 in 1991, ''but it overlooks further information in adjacent sections of the report indicating that there have been ''no changes'' in overall * * * [MSD] incidence'' and that there has been no decrease in MSD-related disabilities (Ex. 32–241–4, p. 233)

OSHA's Response: This case study is a site visit report for a truck terminal operation. The site visit report was prepared in July, 1992 and contained a table that reported numbers of MSDs occurring in 1989 through 1991. OSHA's analysis of ergonomics intervention effectiveness was based on these numbers. Although the report stated that no decline in MSD-related disabilities had been seen, it also stated that the program had been recently implemented (in 1990) and ''its effectiveness may not yet be apparent'' (Ex. 26–1177). A follow-up telephone interview was conducted in January, 1994, at which time the employer indicated subjectively that there were no changes in MSD incidence. However, the employer also reported that the company ''had no hard data to back that up,'' and that no information was available to track changes in workers' compensation claims related to the ergonomics program (Ex. 26–1177, pp. 5–7 & 5–8). Therefore, it is clear that the employer had not been evaluating the performance of their program after 1991, and therefore no conclusions can be reached regarding the effectiveness of the program after 1991, the last year in which OSHA was able to obtain data on MSD injuries. OSHA finds that the quotes cited by Gibson, Dunn & Crutcher are not convincing in establishing that the ergonomics program was ineffective in the 1989–1991 period.

Materials Handling, Electrical Utility (Ex. 26–1085)

Comment: OSHA attributes 100-percent effectiveness to an ergonomics program based on a ''passing reference'' in the case study to eliminating 9 injuries just by getting in and out of vehicles. The article explains elsewhere that the total program is in its 'infancy stage' and the overall asserted effect so far has been to reduce lost-time injuries from more than one per 100 employees to 0.42, only part of which is allegedly attributable to ergonomics.'' (Ex. 32–241–4, pp. 233–234)

OSHA's Response: This case study is a published article describing the ergonomics program at a major utility company. OSHA based its measure of intervention effectiveness on the results of two specific interventions discussed in the article. These are not ''passing references'' but are examples of the earliest interventions implemented by the company:

> ''Downsizing water and ice kegs from 10 to five gallons and lowering their placement on trucks is one way we profited from ergonomic thinking right away * * * Since making the change, we've had no injuries associated with lifting water kegs' (Ex. 26–1085, p. 25).
>
> ''[t]hrough the use of ergonomics, 'we have reduced sprain injuries in several of our operations areas.['] For example, he says, 'we went from nine injuries last year from just getting in and out of trucks and vehicles, to zero this year'' (Ex. 26–1085, p. 25)

The article also makes clear that the ergonomics program is in its 'infancy stage' on the *corporate-wide* level, *i.e.*, that not all problems have been addressed at the time the article was published. For example, the article makes reference to workers who work at bill processing machines for extended periods of time and are at risk of developing carpal tunnel syndrome. Because the program had not yet been fully implemented, OSHA did not base its effectiveness measure on corporate-wide injury statistics (the company reported that total lost-time injuries declined from more than 1 per 100 workers to 0.42 per 100 workers) (Ex. 26–1085, p. 27), but instead based it on the proven effectiveness of the specific interventions discussed in the case study. After considering this comment and reviewing the case study, OSHA finds that this is still a reasonable approach and therefore has continued to include this study in its database.

Auto Air Conditioner Manufacturer Case Study (Ex. 26–1078)

Comment: ''[OSHA] * * * recites two examples from self-interested company officials claiming '50%' and '100%' reductions in 'total MSDs', while ignoring a lengthy description in the same article of scientifically documented experience at a different company showing that 'job improvements' cannot be expected to translate to any reduction in 'the number of back injury claims filed'.'' (Ex. 32–241–4, p. 234, citing Ex. 26–1078, p. 30)

OSHA's Response: The ''scientifically documented experience'' referred to by Gibson, Dunn & Crutcher is a short article by Dr. Stanley Bigos, University of Washington Department of Orthopaedics, describing his results from the Boeing study and the role of psychosocial factors in low back disability. OSHA discusses both the Boeing study and psychosocial factors at length in the Health Effects section (Section V) of this preamble.

UPS Case Study (Ex. 26–1084)

Comment: Steven Thompson, who co-authored a UPS report, ''does not believe that it would be legitimate to cite the article as evidence that ergonomic interventions pursuant to OSHA's proposal would have the effect that OSHA claims'' because, among other things, the article did not attempt to link the observed reduction in reported MSD cases to any particular cause or to account for the Hawthorne effect (Ex. 32–241–4, p. 217).

OSHA's Response: This case study is a published report of the results of an ergonomics program that provided adjustable sit-stand workstations to UPS employees using computer stations to perform a variety of tasks. Benchmark data collected prior to introducing the sit-stand workstations included production levels, absenteeism, survey results on operator comfort, and injury and illness rates. The study reported that injury and illness rates declined by more than 50 percent in the year after introducing the new workstations, and that there were no costs associated with the remaining injuries. In addition, the study reported an average reduction of 62 percent in symptoms of discomfort. There was no change in production level or absenteeism, which the authors believed may be partly explained by poor weather at the beginning [winter] of the follow-up year. In an attachment to Gibson, Dunn & Crutcher's submission, Mr. Thompson of the UPS, one of the co-authors of the study, stated that the article in question ''did not engage in the type of individual cause-and-effect analysis that would be necessary to link the observed reduction in reported MSD cases to the sit-stand workstation as opposed to other non-ergonomic factors.'' Mr. Thompson identifies several factors relating to the moving of the office location to a new building from an ''old crowded building.'' ''The new building had better lighting, ventilation, temperature control, windows, modular doors, and an overall open environment.'' According to Mr. Thompson's statement, the authors of the report ''did not account for the Hawthorne effect in light of these factors'' and other factors, some of which are often, in fact, considered engineering and administrative ergonomic changes.

In the original article, published as part of the *Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting,* the authors, Nerhood and Thompson, do discuss moving employees to a new building to provide a better working environment and providing adjustable sit-stand workstations for those employees ''with the heaviest risk of discomfort'' (Ex. 26–1084, p. 668). The authors also acknowledge the possibility of a Hawthorne effect being a ''contributing factor to any *production* changes'' (Ex. 26–1084, p. 671, emphasis added) because ''the study cycle was too short to hypothesize long term results [on production]'' (Ex. 26–1084, p. 668); however, nowhere in the article do the authors indicate that the Hawthorne effect was or could have been responsible for the observed drop in injury rate or operator discomfort. Despite the non-ergonomic changes in the work environment associated with the new building, the authors concluded that ''[t]he commitment from all groups involved was the key to the successful implementation of the *ergonomics* program and installation of the new adjustable sit-stand workstations'' (Ex. 26–1084, p. 671, emphasis added). Thus, in the original study, the authors attribute the reduction in operator discomfort and injury rate to the ergonomic intervention. Because of the strong conclusion made in the original study, OSHA finds it appropriate to retain this study in its data set.

In their post-hearing brief, Gibson, Dunn & Crutcher describe the testimony of several witnesses as examples of ergonomic interventions that failed (Ex. 500–197, pp. II–20 to II–23). The following summarizes these examples and OSHA's response to Gibson, Dunn & Crutcher's interpretation of the testimony.

Carl Zipfel, Seton Company

Comment: ''Carl Zipfel, Director of Environmental Compliance and Safety for Seton Company, a supplier of automotive interior leather, testified about his company's efforts to help employees who were stretching leather hides over a table and began to complain about shoulder problems. Seton Company tried every measure that OSHA could expect. * * * After all of these efforts no improvements were observed.'' (Ex. 500–197, p. II–20)

OSHA's Response: In his testimony at the informal hearing, Mr. Zipfel provided the following information, which explains why no improvements were observed:

- Under questioning, Mr. Zipfel agreed that Seton had no ergonomics program that would either meet the definition of an existing program under the grandfather clause or that would meet the requirements for an ergonomics program in the standard as proposed (Tr. 3051–3052).
- Although Seton has investigated incidents of MSD symptoms, the company has no one trained to do a job hazard analysis (Tr. 3066).
- Mr. Zipfel stated that Liberty Mutual and Penn State analyzed jobs and prepared reports for Seton regarding the leather stretching problem, but he never discussed what remedies were recommended in those reports or whether Seton tried to implement any of the suggested remedies (Tr. 3059).

There is no evidence in Mr. Zipfel's testimony that indicates that Seton had implemented engineering or administrative controls to address the problem at the leather stretching station; thus, OSHA does not agree that Seton ''tried every measure that OSHA could expect,'' and finds Mr. Zipfel's testimony unpersuasive evidence for the failure of ergonomics interventions.

Robert Willoughby, Boral Bricks

Comment: After implementing Boral's insurance company's suggestion of automating certain jobs in some of his facilities, the ''injury rates are not significantly better than [at] the plants that [have] more manual [jobs]'' (Ex. 500–197, pp. II–20 to II–21, citing Tr. 7776).

OSHA's Response: Mr. Willoughby stated that Boral's insurance company recommended the automation of two jobs: setting green, unfired brick on kiln cars and hand packaging the finished product (Tr. 7745–7746). It is clear from Mr. Willoughby's description that the automated equipment has contributed significantly to reduction in exposure to risk factors. For example, one automated piece of equipment that removes brick from the kiln required employees to stand on top of the cars and bend below knee level to lift bricks and place them into trays. Employees suggested and implemented an approach that prevented the need to bend below knee level but still required workers to lift bricks at waist height using an extended reach (Tr. 7787–7788). In this example, Mr. Willoughby commented without providing evidence, that ''what we have accomplished [from eliminating the deep bend] is going to be offset by the fact of extending the arms'' (Tr. 7788). On the other hand, Mr. Willoughby provided two examples of job fixes that he believed were worthwhile: one involved using pallets to package brick in smaller increments for easier handling, and the other used metal strapping bands and magnetic lifts to reduce the need for manual handling (Tr. 7790–7791). Regarding Boral's overall ergonomics program, Mr. Willoughby testified that he developed a written program a few years ago, but it has not been fully implemented; as part of their overall safety and health program, Boral currently provides information on MSDs, trains employees in recognizing potential hazards, and has safety and health committees at its facilities, some of which actively inspect the workplace and propose improvements (Tr. 7785–7786). Because of the continued exposure of employees to risk factors in jobs that had been automated, and Mr. Willoughby's testimony about the value of some of the interventions implemented by Boral, OSHA does not agree that the experience of Boral Bricks represents a failed ergonomics effort.

Mary Banks, Social Security Administration

Comment: Ms. Banks, a key operator who was diagnosed with DeQuervain's syndrome in 1998, testified that her symptoms have not improved at all and have gotten progressively worse in the year since she was provided with a new workstation. (Ex. 500–197, pp. II–21 citing Tr. 10664).

OSHA's Response: Ms. Banks described the new furniture as ''too little, too late'' for her (Tr. 10690). Her testimony indicated that her condition was quite severe:

> This impairment is devastating at times. I feel pain most of the time. It is difficult for me to pick up anything that weighs more than three pounds. It is hard to reach in back of me, to clap my hands even in church. It is difficult to open an envelope. I cannot pick up my grandbaby without fear of dropping him. (Tr. 10666–10667)

In addition, Ms. Banks was also diagnosed with tendinitis (Tr. 10667), and used only able to use her right hand to key at the time of the hearing (Tr. 10695). She concluded her testimony by stating that, if the ergonomics program had been in place, she would not have developed her condition (Tr. 10667). OSHA does not find that the lack of improvement in Ms. Banks serious upper-extremity disorder after she was issued a new workstation (details of which were not described during her testimony) constitutes adequate evidence that properly designed computer and VDT workstations are ineffective in reducing the risk of developing MSDs among healthy workers.

Dr. Charles Roadman for American Health Care Association

Comment: ''Dr. Roadman testified, however, that 'everything that we have tried has not decreased the incidents of [carpal tunnel syndrome]''' (Ex. 500–197, p. II–21 citing Tr. 4448).

OSHA's Response: Dr. Roadman was not discussing programs that members of the American Health Care Association (AHCA) had instituted to handle carpal tunnel syndrome, but was referring to an Air Force program he had instituted years before when he had been Surgeon General of the Air Force (Tr. at 4448). Although he felt that the interventions he had seen tried with computer users did not seem qualitatively to reduce the incidence of CTS, he also stated that ''that doesn't mean we should not keep trying to do that'' (Tr. 4448). In general, Dr. Roadman has positive things to say about ergonomic programs. He discusses favorably programs that the AHCA created with the assistance of OSHA (Tr. 4355–6). He also stated that ergonomic programs ''can be very positive if all the factors are in place and you have good cooperation * * * between labor and management and the assessment process. Yes, they can be very successful'' (Tr. 4436).

From the examples above, OSHA is not convinced that the testimony cited by Gibson, Dunn & Crutcher demonstrate that ergonomic interventions are ineffective, as a general matter.

BILLING CODE 4510–26–P

Appendix VI-A. BLS Injury Categories Likely To Include Employer-Reported Musculoskeletal Disorders

BLS Code	Nature of Injury	Description
00	Traumatic injuries and disorders, unspecified	This major group classifies traumatic injuries and disorders when the only information available describes the incident as traumatic. For example, employee was hurt in car accident.
01	Traumatic injuries to bones, nerves, spinal cord	This major group classifies traumatic injuries to the bones, nerves, or spinal cord which include breaking and dislocating bones and cartilage and traumatic injury to the brain, spinal cord, and nerves.
011	Dislocations	subluxations; slipped, ruptured, or herniated disc; partial displacement; and fractured or broken cartilage
012	Fractures	closed fractures for which no open wound exists; open fractures for which there is an accompanying open wound; comminuted, compound, depressed, elevated, fissured, greenstick, impacted, linear, march, simple, and spiral fracture; and slipped epiphysis
013	Traumatic injuries to spinal cord	severed spinal cord, nonfatal severed spinal cord resulting from a gunshot wound, traumatic transient paralysis, anterior cord syndrome, lesion of spinal cord, and central cord syndrome
014	Traumatic injuries to nerves, except the spinal cord	This nature group classifies traumatic injuries to nerves other than the spinal cord. Cranial nerves, peripheral nerve of the shoulder or pelvic girdle, and nerves of the limb are possible locations for injuries in this nature group. Diseases or disorders of the nervous system that occur over time as a result of repetitive activity, such as carpal tunnel syndrome, are classified in major group 12. Includes division of nerve, lesion in continuity, traumatic neuroma.
018	Multiple traumatic injuries to bones, nerves, spinal cord	This nature group classifies multiple injuries and disorders of equal severity within Traumatic injuries to bones, nerves, spinal cord, major group 01.

Appendix VI-A. BLS Injury Categories Likely to Include Employer-Reported Musculoskeletal Disorders (continued)

BLS Code	Nature of Injury	Description
019	Traumatic injuries to bones, nerves, spinal cord, n.e.c.	
020	Traumatic injuries to muscles, tendons, ligaments, joints, etc., unspecified	Traumatic injuries that affect the muscles, tendons, ligaments or joints; exact nature of disorder not specified in employer's report.
021**	Sprains, strains, tears	This nature group classifies cases of sprains and strains of muscles, joints tendons, and ligaments. Diseases or disorders affecting the musculoskeletal system, including tendonitis and bursitis, which generally occur over time as a result of repetitive activity should be coded in Musculoskeletal system and connective tissue diseases and disorders, major group 17. Includes avulsion, hemarthrosis,, rupture, strain, sprain, or tear of joint capsule, ligament, muscle, or tendon. Excludes hernia (153), lacerations of tendons in open wounds(034), torn cartilage (011).
029	Injuries to muscles, tendons, ligaments, joints, etc., n.e.c.	This nature group classifies injuries to muscles, tendons, ligaments, etc. that are not classified elsewhere in this major group.
0972** 0973** 0978 0979	Back pain, hurt back Soreness, pain, hurt, except the back Multiple nonspecified injuries and disorders Nonspecified injuries and disorders, n.e.c.	Subcategories under nature group 097, Nonspecified injuries and disorders, which includes traumatic injuries and disorders where some description of the manifestation of the trauma is provided and generally where the part of body has been identified. Subcategory 0972 includes hurt back, backache, low back pain.
099	Other traumatic injuries and disorders, n.e.c.	
1240 1241** 1249	Disorders of the peripheral nervous system, unspecified Carpal tunnel syndrome Other disorders of the peripheral nervous system, n.e.c.	Subcategories under nature group 124, Disorders of the peripheral nervous system, which includes the nerves and ganglia located outside the brain and spinal cord. Subcategory 1249 includes Bell's palsy, tarsal tunnel syndrome, other mononeuritis of the extremities, nontraumatic lesion of the median, ulnar and radial nerves, muscular dystrophies.
1371	Raynaud's syndrome or phenomenon	Subcategory under nature group 137, Diseases of arteries, arterioles, capillaries.

Appendix VI-A. BLS Injury Categories Likely to Include Employer-Reported Musculoskeletal Disorders (continued)

BLS Code	Nature of Injury	Description
153**	Hernia	This nature group classifies hernias of the abdominal cavity. Includes: femoral (1539), esophageal (1539), hiatal (1532), inguinal (1531), paraesophageal (1539) scrotal (1531), umbilical (1539), and ventral (1533) hernias. Excludes: herniated disc (011), herniated brain (1231), and strangulations (091).
17**	Musculoskeletal system and connective tissue diseases and disorders.	This major group classifies diseases of the musculoskeletal system and connective tissue.
170	Musculoskeletal system and connective tissue diseases and disorders, unspecified	
171	Arthropathies and related disorders (arthritis)	This nature group classifies joint diseases and related disorders with or without association with infections. Includes: ankylosis of the joint, arthritis, arthropathy, and polyarthritis. Excludes: disorders of the spine (172), gouty arthropathy (1919), rheumatic fever with heart involvement(131).
172	Dorsopathies	This nature group classifies conditions affecting the back and spine. Includes: spondylitis and spondylosis of the spine (1729); intevertebral disc disorders, except dislocation (1723); sciatica (1721); lumbago (1722); and other nontraumatic backaches (1729). Excludes: dislocated disc (011), curvature of the spine (1741), fractured spine (012), herniated disc (011), ruptured disc (011), traumatic sprains and strains involving the back (021), and other traumatic injuries to muscles, tendons, ligaments, or joints of the back (02), and traumatic back pain or backache (0972).
173	Rheumatism, except the back	This nature group classifies disorders marked by inflammation, degeneration, or metabolic derangement of the connective tissue structure of the body, especially the joints and related structures of muscles, bursae, tendons and fibrous tissue. Generally, these codes should be used when the condition occurred over time as a result of repetitive activity. Includes: rotator cuff syndrome (1739), rupture of synovium (1739), and trigger finger (1739). Excludes: rheumatism affecting the back is included in code (172), traumatic injuries and disorders affecting the muscles,

Appendix VI-A. BLS Injury Categories Likely to Include Employer-Reported Musculoskeletal Disorders (continued)

BLS Code	Nature of Injury	Description
		tendons, ligaments and joints (02).
174	Osteopathies, chondropathies, acquired deformities	This group is comprised of diseases of bones, diseases of cartilage, and acquired musculoskeletal deformities. Includes: osteomyelitis, periostitis and other infections involving bone; and acquired curvature of the spine.
179	Musculoskeletal system and connective tissue diseases and disorders, n.e.c.	This nature group classifies musculoskeletal system and connective tissue diseases and disorders that are not classified elsewhere.
4120	Symptoms involving nervous and musculoskeletal systems, unspecified	Subcategories under nature group 412, Symptoms involving nervous and musculoskeletal systems, which includes symptoms specific to either the nervous or musculoskeletal systems. Subcategory 4129 includes abnormality of gait, lack of coordination, tetany, and meningismus.
4128	Multiple symptoms involving nervous and musculoskeletal systems	
4129	Symptoms involving nervous and musculoskeletal systems, n.e.c.	
414	Symptoms involving head and neck	This nature group classifies symptoms which are specific to either the head or neck. Includes: throat pain (4149), aphasia (4149), and epistaxis/nosebleed (4149).

** Categories included in OSHA's preliminary risk assessment.

Source: Occupational Injury and Illness Classification Manual, Bureau of Labor Statistics, December 1992 (Ex. 26-1272)

Appendix VI-A. BLS Injury Categories Likely To Include Employer-Reported Musculoskeletal Disorders

BLS Code	Nature of Injury	Description
00	Traumatic injuries and disorders, unspecified	This major group classifies traumatic injuries and disorders when the only information available describes the incident as traumatic. For example, employee was hurt in car accident.
01	Traumatic injuries to bones, nerves, spinal cord	This major group classifies traumatic injuries to the bones, nerves, or spinal cord which include breaking and dislocating bones and cartilage and traumatic injury to the brain, spinal cord, and nerves.
011	Dislocations	subluxations; slipped, ruptured, or herniated disc; partial displacement; and fractured or broken cartilage
012	Fractures	closed fractures for which no open wound exists; open fractures for which there is an accompanying open wound; comminuted, compound, depressed, elevated, fissured, greenstick, impacted, linear, march, simple, and spiral fracture; and slipped epiphysis
013	Traumatic injuries to spinal cord	severed spinal cord, nonfatal severed spinal cord resulting from a gunshot wound, traumatic transient paralysis, anterior cord syndrome, lesion of spinal cord, and central cord syndrome
014	Traumatic injuries to nerves, except the spinal cord	This nature group classifies traumatic injuries to nerves other than the spinal cord. Cranial nerves, peripheral nerve of the shoulder or pelvic girdle, and nerves of the limb are possible locations for injuries in this nature group. Diseases or disorders of the nervous system that occur over time as a result of repetitive activity, such as carpal tunnel syndrome, are classified in major group 12. Includes division of nerve, lesion in continuity, traumatic neuroma.
018	Multiple traumatic injuries to bones, nerves, spinal cord	This nature group classifies multiple injuries and disorders of equal severity within Traumatic injuries to bones, nerves, spinal cord, major group 01.

Appendix VI-B. Summary of Case Studies of Ergonomic Programs/Interventions

#	Job Title or Activity	SIC Code	Ergonomic Program/Interventions	Reported Reduction in Injury Rates: Lost Workday MSDs	Reported Reduction in Injury Rates: Total MSDs	Sources
1	Food Packing	20	Implemented full program in 1976 on packing line, including job task analysis, employee involvement in identifying problems and solutions, worker training, and medical management. Job analysis resulted in 56 proposals for changes in equipment and work environment, half of which were implemented in six months.	Not Reported	In 1976, prior to implementing the program, there were 51 hand MSDs identified among 200 packing workers. Hand MSDs were eliminated by 1980, four years after program implementation. Other upper extremity illnesses declined by about 47% in this same time period.	Luopajarvi et al. (1982) (Ex. 26-1042); Luopajarvi et al. (Undated) (Ex. 26-1090)
308	Meat Industry	201	Fleshing machine was modified so workers no longer have to lift and rotate beef to remove the hide.	Lost days were reduced from 126 to 0, saving $9,765 in additional labor and $35,700 in medical and workers' compensation.	CTD incidence rates fell from 7 to 2 cases (71%) and worker comfort increased 30%.	(Ex. 500-114)
197	Meatpacking	2011	The company's ergonomics program addressed small and large problems. A recent big project involved a reconfiguration of the front half of the loin-boning line. This involved changing the direction of the loins coming down the line, from cross ways to length ways. This reduced reach to almost zero for those persons on that end of the line, which had several very ergonomically challenging jobs due to work loads at extended reach creating severe ulnar deviation problems. The company uses safety and ergonomics committees as well as a business improvement team that has been trained in ergonomics.	In 1996,the first year of their re-emphasized ergonomics program they reduced their lost work-day injuries by 81 (compared to 1995), and saved $70,000 in worker's compensation costs. Lost work day injury incidence rates have continued to decline from 1996 to 1998 (33.1 to 28.7).	Not Reported	OSHA case files (Ex: 502-22)

Appendix VI-B. Summary of Case Studies of Ergonomic Programs/Interventions

#	Job Title or Activity	SIC Code	Ergonomic Program/Interventions	Reported Reduction in Injury Rates		Sources
				Lost Workday MSDs	Total MSDs	
198	Meatpacking	2011	This company has developed and implemented a comprehensive ergonomics program as one key ingredient of an overall safety and health program. Employee input is also an important aspect in the company's safety and health program. Ergonomics training was provided to managers, supervisors, lead people, trainers, and production workers. Ergonomic job analyses were completed resulting in the identification of 20 jobs having risk factors associated with upper extremity musculoskeletal disorders. Risk factors were measured and abatement actions were undertaken to reduce these risk factors.	In the first year of their cooperative effort, they reduced their days away from work by 71%, their lost work-day injuries by 19%. This record was achieved despite a 12% increase in hours worked	In the first year of their cooperative effort, they reduced their overall injuries by 40%, sprains and strains by 52%, lacerations by 30%, and cumulative disorders by 32%. This record was achieved despite a 12% increase in hours worked.	OSHA case files (Ex: 502-22)
185	Meat Processing	2011	The company set up an ergonomics committee including management, engineering and production personnel to manage the ergonomics program. An ergonomics checklist was developed for all workstations. The company identified jobs with multiple risk factors and eliminated the risks. The company found ninety-five percent of the work site improvements easy to do. A few, such as installation of an automated deboning machine, required a greater financial investment.	Not Reported	Ergonomic and safety improvements reduced the incidence of OSHA recordable injuries by 17% in one year (1991 to 1992). Medical costs declined 15%.	Putting it on the table," *The National Provisioner*,(October 1992). (Ex: 502-22)

Appendix VI-B. Summary of Case Studies of Ergonomic Programs/Interventions

#	Job Title or Activity	SIC Code	Ergonomic Program/Interventions	Reported Reduction in Injury Rates: Lost Workday MSDs	Reported Reduction in Injury Rates: Total MSDs	Sources
128	Meatpacking	2011	In 1984, the company developed its ergonomics program which includes: *Employee technique *Equipment and workstation design *Administrative controls, such as job rotation *Job analysis. They videotape each worker performing his/her job and then play the tape in slow motion to pinpoint risk factors. These tapes are also used to compile "physical demands assessments" (PDAs). The PDAs essentially quantify a job's requirements, i.e., how much lifting, stretching and reaching will be necessary to perform the tasks involved. PDSs are primarily used to determine whether an injured worker can return to work. *Training. The training, known as the Industrial Athlete Program, includes a two-hour seminar, videotapes and workbook. *Employee suggestions.	Not Reported	CTDs have decreased by 60%, even though the work force has increased by 27%.	James M. Burcke, "Tackling Cumulative Trauma Disorders," *Business Insurance,* (4/18/94). (Ex: 502-22)
5	Meat Preparation	2011	Introduction of engineering controls: redesigned workstation by sloping the work surface toward the meatcutter; introduced rotary cutter and single hooks.	Not Reported	80% reduction in musculoskeletal injuries in the first year.	Oxenburgh (1994) (Ex. 26-1041), Case 45

Appendix VI-B. Summary of Case Studies of Ergonomic Programs/Interventions

#	Job Title or Activity	SIC Code	Ergonomic Program/Interventions	Reported Reduction in Injury Rates		Sources
				Lost Workday MSDs	Total MSDs	
230	Meat Processing	2011	To reduce work-related musculoskeletal disorders in its meat process facility, this company introduced ergonomic hand tools and power tools and mechanized lifting equipment. The company also reviewed and modified production rates and staffing levels.	Not Reported	This company reduced work-related musculoskeletal disorder injury rates from 13.64 per 100 employees in 1989 to 4.37 per 100 employees in 1993.	Corporate settlement agreement report to OSHA (Ex: 502-22)
329	Meatpacking	2011	Implemented a comprehensive ergonomics program. Consist of Labor-management committee, ergonomic monitors, jobs are videotaped for study, workstations are improved where possible, administrative controls were not possible, training of workers' and supervisors.	Worker compensation costs declined by more than 50% between 1988 and 1993.	Diagnosed RSI cases have been reduced by 50%. RSI related surgeries have decreased by 40%.	(Ex: 32-339-1-1)
2	Meatpacker	2011	Training efforts included awareness training of corporate and plant managers and technical training of safety and medical personnel. Ergonomic task forces were established at individual plants to identify problem jobs and implement exposure controls. Controls included use of anti-fatigue mats and manual handling assists such as conveyors and trucks. Job rotation and cross-training of rotated workers were also employed.	Not Reported	Cumulative trauma injuries reduced from four in one month to none reported during a 6-month period.	McCasland (1992) (Ex. 26-1043)

Appendix VI-B. Summary of Case Studies of Ergonomic Programs/Interventions

#	Job Title or Activity	SIC Code	Ergonomic Program/Interventions	Reported Reduction in Injury Rates		Sources
				Lost Workday MSDs	Total MSDs	
220	Meatpacking	2011	In compliance with their settlement agreement, this company established a comprehensive ergonomics program with elements that included: training, recordkeeping, job analyses, and medical management. NIOSH and OSHA made several site visits to assist with program implementation.	Not Reported	After establishing a comprehensive ergonomic program, ergonomic injuries declined by more than 85 percent. These declined as follows: 1988–364; 1990–189; 1993–89.	OSHA case file documentation (Ex: 502-22)
4	Meatpacker	2011	Implementation of an ergonomics program, including engineering controls, work hardening program, training, and medical management.	Not Reported	CTDs decreased from 47.8 per 100 workers (1987) to 17.2/100 workers (1990) and 17.7/100 workers (1991).	OSHA Site Visit Case Study No. 2 (26-1175)

Appendix VI-B. Summary of Case Studies of Ergonomic Programs/Interventions

#	Job Title or Activity	SIC Code	Ergonomic Program/Interventions	Reported Reduction in Injury Rates: Lost Workday MSDs	Reported Reduction in Injury Rates: Total MSDs	Sources
235	Turkey Processing	2015	Each employee is involved in applying ergonomic principles with those designated as Employee Ergonomic Specialists receiving training. Company is providing support for the program in the form of capital, time, human resources, and technical support. Job duties are ranked on an ongoing basis by the Specialists. Each year one high-stress task is targeted for modification in one or more of the following: reduction or elimination of the manual task through automation, obtain additional material handling equipment, modify the work station, and increase staff while other options are being implemented. It is the company's policy to use rotation on a limited basis and instead opt for reducing or eliminating the ergonomic hazard. Supervisors and managers have the authority to make immediate decisions for the removal or correction of ergonomic hazards.	From 1995 to 1997, this large processor cut their ergonomic-related lost-work-day injury rate by 50% and their total lost - work-day injury rate by more than 40%.	Not Reported	OSHA case files (Ex: 502-22)

Appendix VI-B. Summary of Case Studies of Ergonomic Programs/Interventions

#	Job Title or Activity	SIC Code	Ergonomic Program/Interventions	Reported Reduction in Injury Rates: Lost Workday MSDs	Reported Reduction in Injury Rates: Total MSDs	Sources
256	Poultry Processor	2015	Initiated a corporate-wide ergonomics program in 1990 consisting of a comprehensive set of core program elements, including management commitment; employee involvement on joint labor-management ergonomics committees; training of employees and supervisors; evaluation of problem jobs by the ergonomics committee followed by implementation of control measures (some "quick fix"); identification of problem jobs using OSHA recordable MSDs and responding to employee reports of symptoms associated with musculoskeletal disorders; seeking worker input on the nature of problems with their jobs and possible interventions; medical management for employees with musculoskeletal disorders; and an annual evaluation of the entire ergonomics program.	Five years after initiation of the program, the incidence of workers' compensation claims for upper extremity MSDs fell by 46% and severity of the claims (cost of claim per 200,000 work hours) fell by 20%.	All repeated trauma cases, recordable on OSHA 200 logs, dropped from 5.55 in 1991 to 3.77 per 100 employees while the incidence of repeated trauma cases with days away from work fell from 0.73 per 100 workers in 1991 to 0.51 in 1994.	Appendix C "Summaries of Studies on Effective Ergonomics Programs and Interventions" (Jones 1997). (Ex:32-339-1)
291	Poultry	2015	Instituted a corporate ergonomics program which utilizes ergonomic committees. Key elements included training, work site analysis and task design, and a medical management process.	Not Reported	46% decrease in upper extremity MSD rates over a five-year period.	Testimony of Bradley Evanoff, MD, MPH. (Ex. 37-1)

Appendix VI-B. Summary of Case Studies of Ergonomic Programs/Interventions

#	Job Title or Activity	SIC Code	Ergonomic Program/Interventions	Reported Reduction in Injury Rates		Sources
				Lost Workday MSDs	Total MSDs	
372	Poultry Slaughtering Employees	2015	Established a comprehensive ergonomics program which consisted of; awareness and training, medical management and early intervention, employee involvement, identification of high risk jobs, engineering and administrative controls, and job conditioning.	In three years from the time the ergonomics program was initiated, workers compensation costs were reduced by two-thirds. Total lost workdays were practically eliminated.	In three years from the time the ergonomics program was initiated, workplace injuries due to cumulative trauma disorders were reduced by two thirds.	(Ex. 502-404)
310	Poultry Processing Plant.	2015	A back-injury reduction program was initiated. This is an ongoing continuous improvement effort in ergonomics.	Not Reported	An 80% reduction in back injuries was achieved over a 4-year period.	(Ex. 500-114)
6	Poultry Processing	2015	Implementation of an ergonomics program, including redesign of processing lines, use of rubber-matted stools and platforms of varying heights to eliminate awkward reaches, worker training, and job reassignment for injured workers.	Not Reported	Decline in upper- extremity and neck/shoulder injuries from about 32 per month to 0.	Farr (1991) (Ex. 26-1044)
135	Poultry Processing	2015	In 1989, the company established a comprehensive ergonomics program at their mill. That program was later strengthened and its major program elements were: ergonomics training and education; medical management, including an emphasis on early reporting; employee involvement and identification of high risk jobs, hazard analyses of them, and implementation of engineering and/or administrative controls for them.	Within three years of initiating their comprehensive ergonomics program, not only were ergonomic related injuries down, but the productivity of their employees was up, the quality of their products had improved, their employee turnover rate had been cut in half, and their comprehensive health care costs had decreased 280%.	Not Reported	*Broiler Industry*, (February, 1992). (Ex: 502-22)

Appendix VI-B. Summary of Case Studies of Ergonomic Programs/Interventions

#	Job Title or Activity	SIC Code	Ergonomic Program/Interventions	Reported Reduction in Injury Rates		Sources
				Lost Workday MSDs	Total MSDs	
202	Poultry Slaughtering	2015	In 1990 the company established a comprehensive ergonomics program at one of their plants. The major elements of their program were: *Ergonomic awareness training/education *Medical management/early intervention *Employee involvement/Ergonomic Committee & Task Forces *Identifying high risk jobs *Implementing engineering and/or administrative controls *Job conditioning	In three years from the time the ergonomics program was initiated, workers' compensation costs and workplace injuries due to cumulative trauma disorders were reduced by two thirds. Lost workdays were practically eliminated.	Not Reported	Correspondence, Perdue Director of Safety,(Nov. 17, 1994). (Ex: 502-22)
8	Poultry Processing	2015	Introduction of engineering controls: tool/handle redesign; work practice controls; administrative controls.	Not Reported	Recordable injuries and illnesses decreased from 10-14/100 workers (1988-89) to 7/100 workers (1991).	OSHA Site Visit Case Study No. 1 (Ex. 26-1174)
7	Poultry Processing	2015	Introduction of workstation analysis and redesign, including altering heights of products, providing workstands, and installing tank tilters to reduce manual handling. Program also included worker training and development of an integrated medical management/surveillance-analysis system.	Not Reported	Carpal tunnel incidence rates decreased from 7.8 per 200,000 hours to between 2.4 and 3.7 per 200,000 hours. Back injury rates declined from 4.4 per 200,000 hours to 3.0 per 200,000 hours.	Stuart-Buttle (1994) (Ex. 26-1045)

Appendix VI-B. Summary of Case Studies of Ergonomic Programs/Interventions

#	Job Title or Activity	SIC Code	Ergonomic Program/Interventions	Reported Reduction in Injury Rates		Sources
				Lost Workday MSDs	Total MSDs	
193	Poultry Slaughterhouse	2015	A program following OSHA's red-meatpacking guidelines was initiatcd in 1992. An crgonomic committee was established in each department and meets monthly. Line supervisors were trained as trainers and trained their employees. A comprehensive medical management program with regular exams and modified work programs based on them was introduced.	Workers' compensation costs went from $.40 per work hour before 1992 to $.07 per hour now.	Carpal tunnel injuries, which averaged between 20 to 30 a year prior to 1992, have averaged less than 2 a year since then.	Douglas Rapp, Complex Safety Director, Tyson Foods of Monett, Phone Conversation:(7/13/99), (417) 235-9351. (Ex: 502-22)

Appendix VI-B. Summary of Case Studies of Ergonomic Programs/Interventions

#	Job Title or Activity	SIC Code	Ergonomic Program/Interventions	Reported Reduction in Injury Rates		Sources
				Lost Workday MSDs	Total MSDs	
191	Poultry Slaughtering	2015	The company brought in a professional ergonomics consultant to give them guidance on setting up a comprehensive program and to do a job-by-job ergonomic safety analysis of the facility. The consultant returns annually for a day-long program review. The training program is for new employees and is repeated once a year for all employees. It is a general overview that stresses the importance of early reporting. They established a medical management program and rely on two ergonomically-trained EMTs. They use job rotations at the first sign of symptoms. Job rotation is used routinely for some high stressor jobs such as deboning but due to employee resistance it is not widely used. They have a plant ergonomic committee to do ongoing job analysis.	Their ergonomic-related lost workday rate has gone from 86.9 in 1993 to 1.0 in 1998.	Their total recordable injury and illness rate has decreased 75% between 1993 and 1998. Their ergonomic-related incidence rate has fallen over 80%.	Spencer Cheak, Director of Human Resources and Safety, Marshall Durbin Food Corp., Hattiesburg, MS, phone conversation, (7/23/99), (205) 956-3505. (Ex: 502-22)

Appendix VI-B. Summary of Case Studies of Ergonomic Programs/Interventions

#	Job Title or Activity	SIC Code	Ergonomic Program/Interventions	Reported Reduction in Injury Rates: Lost Workday MSDs	Reported Reduction in Injury Rates: Total MSDs	Sources
9	Ice Cream Manufacture, Various Jobs	2024	Performed job hazard analysis, implemented several controls including use of non-skid elevating platforms for shorter workers; modified workspace layout to permit workers to move without being hindered; replaced sharp edges of equipment with sloping angles or padding; replace hygienic thin-filmed gloves with warm, flexible gloves; modified way employees performed lifting and carrying tasks.	In 1985, before implementing the program, there were 4 compensation claims and absenteeism equaled 10 % of shifts worked. In 1987, there were no compensation claims and absenteeism was reduced to 4% of shifts worked.	Not Reported	Elie (OH&S Canada, Vol. 4, No. 7) (Ex. 26-1100)
10	Cattle Feed Processing Operation	2048	Provided a forklift and a bobcat to eliminate manual lifting and relocated the feed mixer in order to install chutes and augers to permit mechanical loading of feed. Installed bulk storage containers so that additives could be gravity-fed to the mixer. Constructed a platform under the auger equal in height to the truck platform, which allowed feed bags to be filled without manual lifting. Program also included providing lifting and handling training to workers.	Not Reported	The company eliminated manual handling injuries.	Teleki (1995) (Ex. 26-1046)
11	Bakery	205	Engineering controls: workstation redesign, tool modifications; improved work practices; formation of labor-management CTD committee.	Absenteeism related to carpal tunnel syndrome decreased from 731 lost work days (1987) to 8 lost work days (Jan.-Aug., 1991).	Carpal tunnel cases decreased from 34 (1987) to 13 (1990).	Robinson (1993) (Ex. 26-1102) (Ex. 38-65) (Ex. 32-339-1-1)

Appendix VI-B. Summary of Case Studies of Ergonomic Programs/Interventions

#	Job Title or Activity	SIC Code	Ergonomic Program/Interventions	Reported Reduction in Injury Rates		Sources
				Lost Workday MSDs	Total MSDs	
162	Bakery	2051	They decided to use a homespun approach to implement a preventive ergonomics program. They brought in a hand surgeon to evaluate their procedures. They formed a joint labor management cumulative trauma disorder committee. Their assembly lines and the way the employees worked were changed. Conveyor belts were moved close to workers; pallets were also moved closer. Tables were raised and lowered; stools were added for employees who used to stoop; mats and foot rests were added. Preventive medical screening for early carpal tunnel syndrome was initiated.	Lost workdays almost eliminated. The company estimated they saved $750,000 annually on workers' compensation costs.	In three years after initiating the ergonomics program, carpal tunnel cases have been cut by 60%.	*Wall St. Journal,* (10/07/92) (Ex: 502-22)
12	Packaging Sugar Cubes	206	Cubes were packed tightly using a hand tool that required worker to exert considerable pressure on a sharp corner edge. Company changed marketing strategy that permitted cubes to be packed loosely, avoiding use of excessive hand force.	Considerable reduction in sickness absence and workers' compensation claims.	Serious strain injuries to hands were "virtually" eliminated.	Oxenburgh (1994) (Ex. 26-1041), Case 41
376	Chocolate Manufacturer	2064	The company determined that it needed to purchase eight different styles of scissors to eliminate employee pain.	Reduced workers' compensation costs by 90%.	Reduced its incidence rate of accidents by 55%.	(Ex. 502-404)